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Farm Power for 75 Years

Gas Tractors for 35 Years

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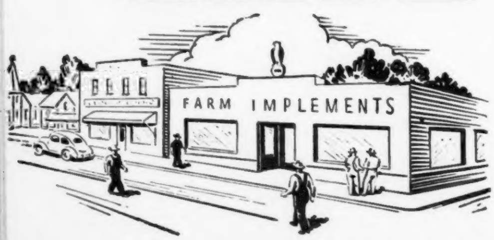

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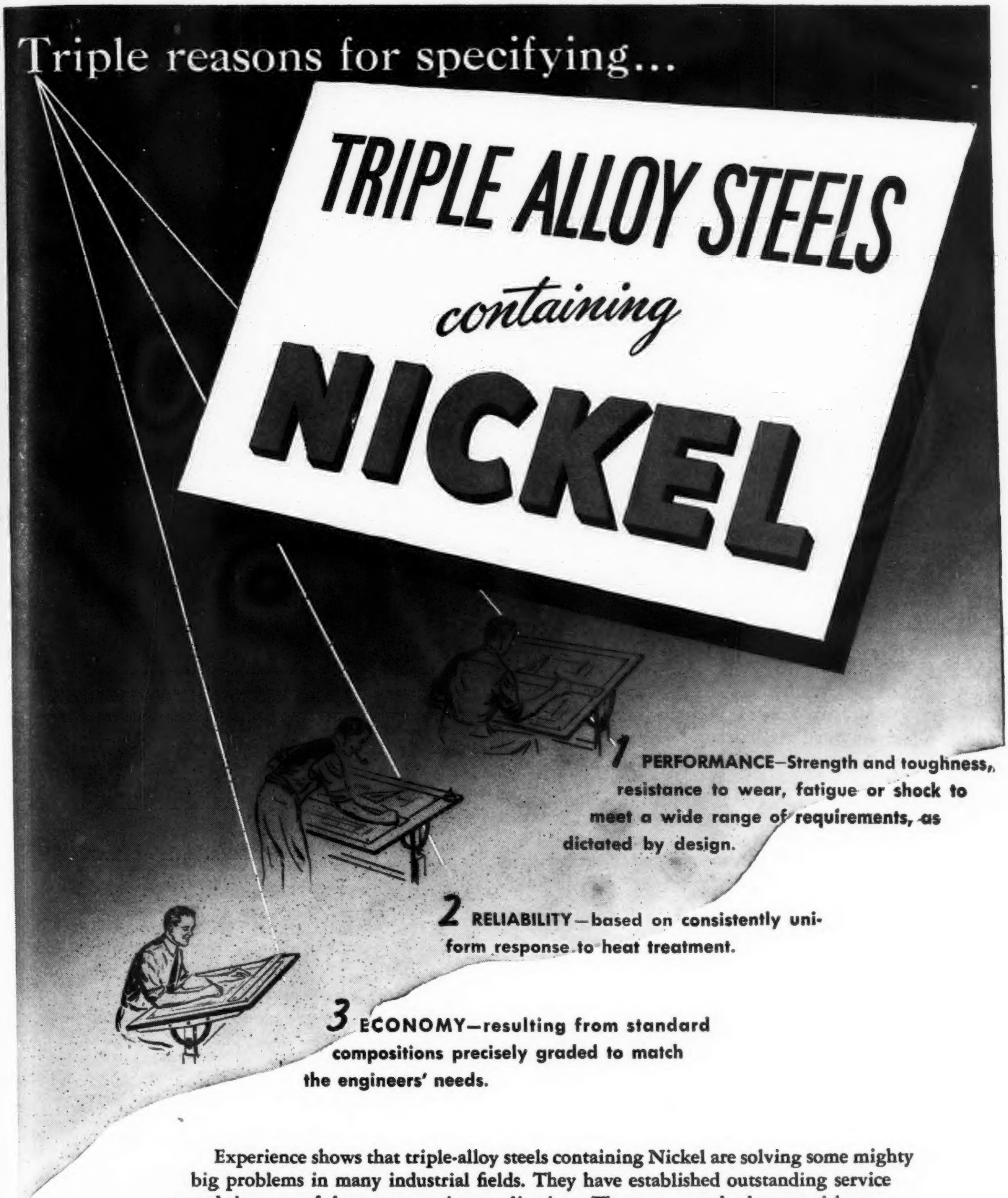

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AGRICULTURAL ENGINEERING

Established 1920

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EDITORIAL

The Purdue Papers

WITH this issue we begin the publication of papers presented at the barn hay-curing conference recently held at Purdue University under sponsorship of the American Society of Agricultural Engineers. In this and two succeeding issues we expect to present not only all of the papers, but a fairly adequate digest of the accompanying discussions. Due to the profusion, not to say prolixity, of such discussion it would be neither feasible nor generally useful to reproduce it verbatim.

Such selection and condensation involves editorial discretion which cannot possibly equal the sum total of technical talent represented in the discussions. Obviously there will be some errors of omission and inclusion, as well as inaccuracy of restatement. We hope that these inevitable faults will be trivial in comparison with the saving of readers' time by an orderly and concise presentation.

The swift progress of barn curing of hay has been almost breath-taking. From the first few faltering experiments to the present fund of quantative data has taken little more than a decade, or perhaps twenty opportunities for observation. No wonder there still remain many areas of ignorance, many conflicts of theory, clashes of opinion and economic questions. Far from deploring spirited differences, we deem them evidence of the virility with which complex problems are being threshed out.

Ramifications of these problems and opportunities reflect anew the logical integrality of agricultural engineering. Obvious, of course, is the interlocking of farm structural design with rural electric practices. Just as real is the impact of barn curing on equipment for making, hauling and handling hay. Less obvious, but more profound, are the implications of improved forage management in relation to soil conservation.

Rivalry in good works will inspire better field curing and silage practices. All will make their contribution toward higher nutritional standards for the nation, as well as toward a higher estate for the farmer.

The Harvester Research Center

THE age-old ideal of turning swords into plowshares finds new expression in the creation of a research center by the International Harvester Company. Recent announcement tells that a war plant is being taken over and will afford nearly a quarter million feet of floor space for centralized and coordinated research to serve all of the company's diverse and far-flung plants and products.

According to our information, the research center will focus its work on the manufacturing phase. This may seem something apart from the strict subject matter of agricultural engineering, concerned chiefly with the design, development and application of farm power and machinery. Yet the broad objectives of reducing manufacturing costs and improving the materials and processes employed are bound to open new avenues to the agricultural engineer.

We know too well how many a machine, technically feasible, has withered on the vine because its cost was too high for adoption by an agriculture operating under ceilings set not by edict but by world economics. Every expedient whereby manufacturing costs can be cut down will admit more machines to economic usage. Such progress is particularly timely now when inflation is on the march with few voices wise enough, or brave enough, to speak plainly about its true causes.

Obviously such research must be directed to the company's own plans and problems, and must be solvent on that basis. But there is abundant precedent for prediction that from such research will flow many benefits to other companies and other industries. Indeed, in the light of the patent-sharing policy adopted by this company, it may well be that similar sharing of research results will be encouraged rather than resisted.

If other companies also push the conduct and sharing of research, we may look for a general and rapid advance all along the farm equipment front. Certainly such will be the devout wish of the agricultural engineering profession.

Prefabrication vs. Inflation

REPLICATED no doubt dozens of times among younger members of the American Society of Agricultural Engineers, and the children of those older, is the expedient recently brought to our attention by one of the latter. His son, utterly unable to find rentable quarters for his family (including two small children) on return from armed service to point of employment, rebelled at the pricing of modest homes for sale, and bought a trailer.

Admittedly cramped for room and lacking in certain facilities, it yet provides livable shelter for about one-third the price of the smallest and flimsiest of homes offered for sale in that community. In lieu of the lot on which such a home stands, the trailer offers roadworthy mobility. No matter what discounts and corrections be applied, it would seem that the trailer provides substantially more living facility per dollar of investment.

Reason for the difference becomes speedily apparent if we contemplate the construction of the trailer, not in the factory but with hand tools, from traditional building materials dumped at the point of use — if indeed, it were possible to construct a roadworthy trailer from such materials. It all exemplifies the economy inherent in factory manufacture, with the materials, machines, and management which it employs.

Implicit, of course, in our usual concept of modern manufacture is standardized design. In our habitual attitude toward our dwellings this has been a serious obstacle to prefabrication. But for many farm structures, especially smaller ones such as brooder houses and colony shelters, it can be a great asset if — and it is a vital "if" — the standard design is really engineered for functional efficiency.

Notable papers, printed from time to time in these pages, have pointed toward optimum and standardized modules in the dimensions of larger farm buildings, as well as some pretty definite features of design. Assembly of such structures from factory-built units would seem to deserve study, as well as freedom from restraints of custom and coercion.

Our plea for prefabrication is not for its own sake, but for the economies which it seems to promise if given a fair chance. Every other avenue toward lower-cost buildings should have consideration and equal opportunity. Unless substantial savings in man-hours can be achieved to offset wage inflation, at hand and ahead, there is reason to fear another stalemate in farm building such as prevailed in the period between the wars.

Even if that fear should happily prove to be unfounded, new economy in farm construction is greatly to be desired. In the economics of earnings from investment, as well as in the psychology of farm planning, it would expand the place for modern farm structures.

Suggestions for Remodeling Room Interiors with Plywood

Check foundation and sub-floor. Replace any damaged portions, and build up where necessary to level floor.

Check Roof condition, and repair or reshingle if needed.

Measure room carefully, and draw plan to scale showing door and window openings and any cabinets or equipment to be built-in. If plywood panels are to have V-edges or decorative battens or mouldings at the joints, draw ceiling plan and wall elevations and lay out attractive panel arrangement.

Remove all trim—door and window casings, baseboard, etc. Eliminate any unnecessary projections to secure smooth wall and ceiling surfaces.

Check operating condition of door and window hardware.

If wall and ceiling surfaces are reasonably true plywood panels may be placed directly over them and nailed through to the framing. Panels may be fastened with finish nails of proper length. Space nails 4" o.c. along panel edges and 8" o.c. at intermediate points. Set nails flush with panel.

If smooth wall for painting or papering is desired, or if old wall or ceiling surfaces are out of line, nail 4" strips cut from extra plywood panel over old walls and ceilings to center on all panel joints, and shim out to a true surface. Similar strips should be placed 16" o.c. in intermediate spaces. If placed at right angles to face grain of panels to be attached to them they give more support. All strips should be firmly nailed to framing with large finish or 6-d box nails. Cut panels to required size and shape. Mix casein glue according to manufacturer's directions and spread over just enough strips to attach one panel at a time. Plumb or level panels carefully and nail against glued strips with finish nails spaced 4" o.c. at edges and 8" o.c. elsewhere. It is advisable to set nails below surface and to fill nail holes with putty or wood mastic. Any openings at the joints may be filled with sawdust mixed with a little glue, scraped flush, and sanded lightly after drying.

Plywood panels for either installation method may be ¼" thickness, but ⅜" thickness is recommended. Panels should be INTERIOR (Moisture Resistant) type, Sound One Side grade.

Panels should be cut flush or slightly short of inside edge of door and window jambs. Rounding such panel edges slightly gives an attractive, simple finish without casings. Thin, narrow casings or mouldings may be placed around openings, if desired.

Ceiling panels may be installed similar to wall panels, with cut-outs as required for lighting fixtures.

Cabinet work may be built in place, using fir plywood panels of suitable thickness for the various parts. A ½" thick EXTERIOR type panel for the kitchen drain board and all other counter surfaces makes an excellent base for a linoleum top.

For a smooth, durable linoleum floor lay ¼" fir plywood panels over the old wood flooring as a base. Fit panels in place with closely butted joints and nail with 4-d box nails spaced 6" o.c. at all panel edges and 12" o.c. elsewhere. Cement linoleum over felt to plywood base as in standard practice.

Specifications and directions for finishing, and other paneling suggestions are available from the Douglas Fir Plywood Association, Tacoma 2, Wash.

DOUGLAS FIR PLYWOOD
LARGE, LIGHT, STRONG.
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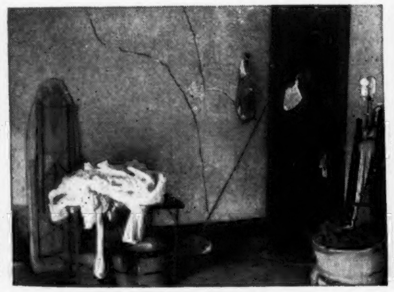
PANELS

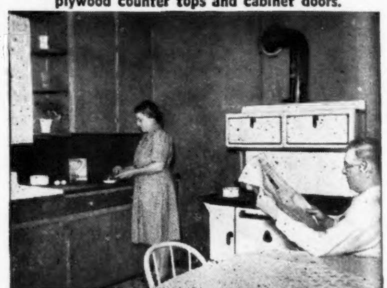
1 The H. E. Marshall farm home near St. Paris, Ohio, needed remodeling.



2 After discussions with the Extension Agricultural Engineer and the County Home Demonstration Agent a storeroom was selected as being the best located room for the new kitchen.

3 In remodeling the room Mr. Marshall removed the trim and baseboard on exposed walls, nailed strips to the studding and ceiling joists, and laid plywood panels lengthwise over these.

4 Kitchen millwork was built in place using plywood counter tops and cabinet doors.



5 Decorative mouldings were used over the wall panel joints. Linoleum was laid on the counter tops and on a plywood base over the old floor. A light stain on the woodwork photographed dark; it may be painted later.

6 In the remodeled home the new kitchen is in the ell at the left.

AGRICULTURAL ENGINEERING

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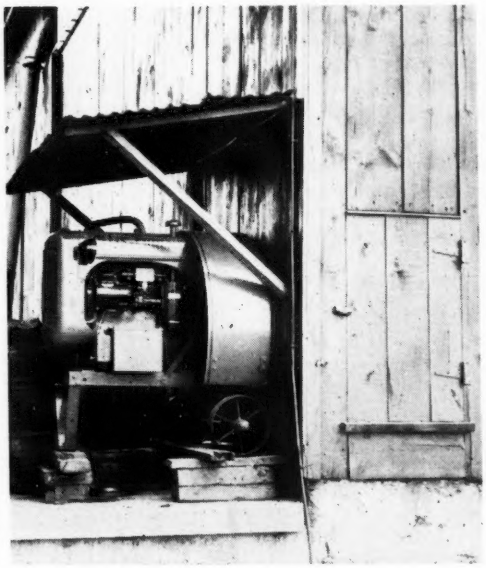
Factors Controlling the Rate of Moisture Removal in Barn Hay-Curing Systems

By C. E. Frudden
MEMBER A.S.A.E.

DURING the past few years there have been many batches of hay produced by the barn-curing method which have been of excellent quality. There have also been some unsatisfactory experiences and generally these have involved an objectionable amount of mold growth in some of the upper layers which were slow to dry.

Spoilage of hay, due to harmful action by bacteria during the drying period, has occasionally been experienced, but this occurs only when the circulation of air through the hay has been stopped for too long a period and the temperature of the hay, accordingly, has reached abnormal heights. In any well-designed and properly operated system the temperature of the hay never reaches a level at which bacteria will become objectionably active.



This picture shows a portable Allis-Chalmers engine-blower unit set up for curing hay in the mow. The unit delivers 20,000 cfm against 1½ in of static pressure. Waste heat from the engine increases the air temperature and speeds up drying

To achieve successful drying of hay by the barn-curing method it is only necessary to blow air of predetermined condition (temperature and humidity) and of predetermined quantity through the hay, so that the hay will become safely dry before the growth of mold develops. Whether the hay is completely dried "in the sun" or partially dried in this manner, and then finish dried in the mow, the process of drying is in both cases the same; namely, unsaturated air is blown through the hay by natural winds or by fans, causing evaporation of moisture from the surface of the hay. The process continues until respiration stops and until sufficient moisture is removed to discourage the growth of mold.

As just stated, drying must be completed within the period of time required for the growth of mold, and this period seems to be fairly well established as a result of a series of tests conducted by A. B. Jennings, agricultural engineer, Cornell University at Ithaca, N. Y., during 1944 and 1945. One hundred or more individual tests are involved, some of which are reported in his "Progress Report on Mow Curing of Hay, No. 824." These tests involved most of the variables that may be encountered in hay-drying practice. Initial moisture in the hay when placed in the mow varied from 40 to 67 per cent. Air velocities through the hay varied from less than 10 cfm per sq ft to over 30 cfm per sq ft. Different kinds of hay were used, and weather conditions as they affect the rate of drying varied from a very favorable period, which averaged 73F and 58 per cent humidity, to an unfavorable period averaging 78F and 77 per cent humidity.

Jennings' tests, as reported in 1944, indicate that any combination of drying influences which will remove moisture at a rate such that a reduction to 10 per cent moisture in the hay will be obtained in less than seven days will produce good quality hay, and any slower rate of drying

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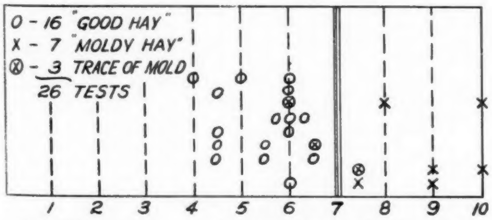
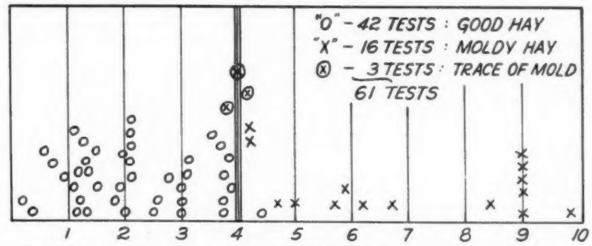
This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

C. E. FRUDDEN is consulting engineer, tractor division, Allis-Chalmers Mfg. Co.



ELAPSED TIME: DAYS REQUIRED TO REDUCE HAY TO 10% MOISTURE (DEPTH OF HAY = 4 FEET)

FIG. 1



ELAPSED TIME: DAYS REQUIRED TO REDUCE HAY TO 20% MOISTURE (AVERAGE)

FIG. 2

will permit mold to grow. Some twenty-six representative tests from the Jennings' 1944 series of tests are shown graphically in Fig. 1.

Jennings' tests during 1945 are reported here in Fig. 2 on the basis of time required to dry the hay to an "average" of 20 per cent moisture. (It may be assumed that, for an average of 20 per cent, the upper layers may have contained 25 to 30 per cent moisture.) This series of tests indicate that the rate of drying, to insure good quality hay, must be such that an average of 20 per cent (on top layers 25 to 30 per cent) must be obtained in four days. Essentially this is the same *rate* of drying as is indicated in Fig. 1. Since the barn-curing system generally results in hay dried to 10 or 12 per cent moisture, it seems quite logical that in the design and operation of any system capacity must be provided which will dry each layer of hay placed in the mow down to 10 per cent within seven days in order to insure good quality hay, free from mold.

The rate at which moisture is removed from the hay is dependent upon the following factors:

1 The quantity or rate of air flow through the hay

2 The "condition" of the air, namely, its temperature and humidity

3 The heat generated by the action of bacteria

4 The heat equivalent of some portion of the power required to drive the fan.

Although items (3) and (4) may represent 10 to 15 per cent of the total drying factors, they will be omitted from further consideration here and treated as so much "velvet" which may be needed to offset errors in design or careless operation.

The process of drying is assumed to be in accord with the following description:

1 The actual drying zone, when air is blown through a deep mass of hay, is a narrow band or layer perhaps one foot in thickness. Below this zone the hay is dry, and above this zone the hay remains in essentially the same condition as when first placed in the mow. This zone moves upward slowly as the hay dries, usually at a rate of about six inches to one foot per day, depending upon conditions.

2 The ability of the moisture within the hay plant to reach the surface, where it is evaporated, is not a limiting factor in the rate of evaporation, except toward the end of the drying cycle.

3 The amount of moisture which the air "picks up," or in other words, the relative humidity of the air after passing through the damp hay, varies throughout the cycle. It approaches 100 per cent when considerable very damp hay is placed in the mow, and at the end of the drying cycle it is only slightly higher than the entering air. Observations of many systems in operation indicate that, for engineering estimates, the outgoing air may be assumed to be 85 per cent relative humidity throughout the drying period.

Based on the above description, Fig. 4 has been prepared from psychrometric charts to indicate the amount of moisture which will be evaporated and carried off in pounds per hour per 1000 cfm under varying conditions of temperature and humidity for the entering air. Knowing the average temperature and humidity for any twenty-four hour period, the probable water evaporation per day can be quickly determined. On the chart are fourteen "dots" which indicate the average temperature and humidity for roughly one week periods during 1944 and 1945 as reported in the Jennings' tests already referred to. The most favorable drying period indicated an evaporation rate of 7

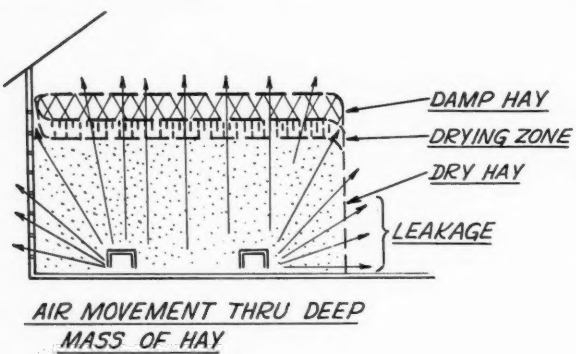


FIG. 3

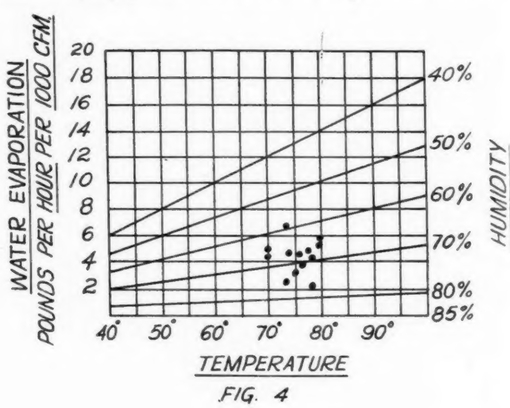


FIG. 4

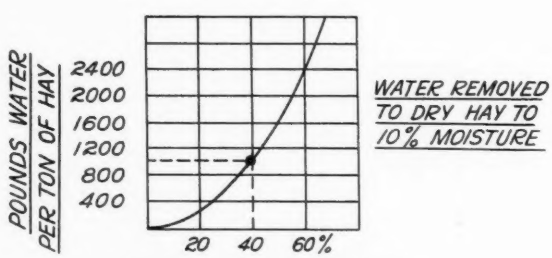


FIG. 5

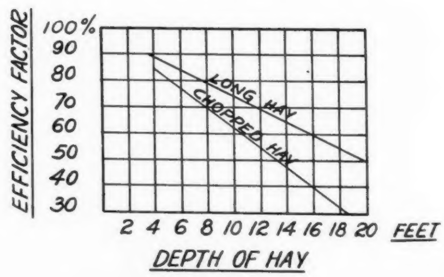


FIG. 6

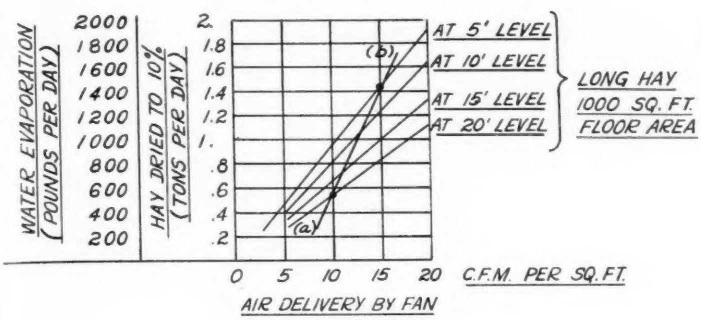


FIG 7

lb per hr per 1000 cfm, the most unfavorable, 2 lb per hr per 1000 cfm. The average is 4.5 lb per hr per 1000 cfm or 108 lb per day per 1000 cfm.

Fig. 5 shown, for purpose of reference, indicates the relationship between the initial moisture in the hay and the amount of moisture required to be removed per ton of dried hay at 10 per cent moisture. (Hay with 40 per cent initial moisture requires the removal of 1000 lb of water per ton of dried hay.)

Air leakage along the floor, sidewalls and posts reduces the effectiveness of the air handled by the fan as the depth of hay increases. Only that air which passes through damp hay will "pick up" moisture. Any air that escapes to atmosphere through hay already dry represents a dead loss, and the overall efficiency is reduced correspondingly. This loss always exists to some degree. It is minimum when the walls of the haymow are smooth and airtight with the hay carefully tramped next to the walls. It is maximum when the sidewalls are open or provided with large cracks which permit free flow of air to the outside. Chopped hay, offering greater resistance to air flow than long hay, is subject to greater losses in this respect. Obviously, as the depth of hay is increased, leakage becomes a greater factor, and efficiency is correspondingly reduced.

In order to recognize this factor Fig. 6 is submitted. It is at best only a rough guess for average conditions and indicates the ratio of air delivered at any level in the mow to the air delivered by the fan. Obviously this chart then indicates an "efficiency factor" which must be applied to Fig. 4. For example, if Fig. 4 indicates an evaporation rate of 5 lb per hr per 1000 cfm and the hay is 15 ft deep, the efficiency may be only 60 per cent, and accordingly only 3 lb per hr per 1000 cfm will be evaporated when the "drying zone" reaches the 15-ft level. This chart is submitted simply to indicate a trend and to indicate one of the factors concerned with the drying problem. The data is not presumed to be absolute.

In order to get some over-all picture of the combined effects of the various factors so far discussed, and to get a proper sense of proportion for each of the various factors, a specific example may serve a good purpose. Let us assume a typical case:

(1) Floor area, 1000 sq ft

(2) Long hay having a density, when dry and settled, of 450 cu ft per ton is assumed for this example

(3) Moisture in hay — initial, 40 per cent
" " " — final, 10 per cent

(4) Water evaporation per ton of hay, 1000 lb

(5) Average atmospheric conditions: The same as the average of Jennings' tests in 1944 and 1945.

Fig. 4, at 75 F average temperature and 68 per cent average humidity, indicates 4.5 lb of water evaporated per hour, or 108 lb per day per 1000 cfm at 100 per cent efficiency. Air delivered by the fan at a rate of 15 cfm per sq ft multiplied by 1000 sq ft equals 15,000 cfm, and a water evaporation of 1620 lb per day at 100 per cent efficiency, which is equivalent to drying 1.62 tons of hay per day.

Fig. 6 indicates the efficiency factor which must be applied for different depths of hay. At 10 feet depth, efficiency is assumed to be 75 per cent; at 15 feet, 63 per cent.

Fig. 7 shows the rate of water evaporation or tons of hay dried per day at different air velocities and at different levels in the haymow. It is to be noted that for 15 cfm per sq ft fan delivery, the drying is at a rate of 1.4 tons per day for hay 5 feet deep, but only 0.8 ton per day at a 20-ft level. This assumes constant air delivery by the fan, whereas in actual practice resistance to air flow increases as the depth of hay increases and the fan delivery is reduced accordingly. If, for example, the fan delivers 15,000 cfm into a mass of hay 5 feet deep, it probably will deliver no more than 10,000 cfm into hay 20 feet deep, and in that case water evaporation will fall along the line (a) - (b) from 1.4 tons of hay dried per day to 0.5 tons per day.

The condition shown by Fig. 7 is considerably aggravated when it is attempted to dry chopped hay because of its greater density and correspondingly greater resistance to air flow. Chopping hay into minimum lengths of 1½ to 2 in is preferable to shorter cuts from the standpoint of air flow resistance.

In summarizing the statements made in this paper it would appear that:

1 All damp hay placed in the mow must be reduced in moisture at a rate to reach 10 per cent within seven days in order to insure hay free from mold.

2 The "condition" of the air (its temperature and humidity) and the quantity of air passing through the drying zone of the hay determine the rate of moisture removal.

3 Leakage or loss of air, through paths of lower resistance, reduces the quantity of air passing through the drying zone and reduces the rate of drying in proportion to the amount of leakage. Not all of the air delivered by the fan is effectively used for drying.

4 Leakage of air increases as the depth of hay increases. There are limitations to the successful application of duct systems which deliver air at the floor line, requiring and expecting the air to move vertically through the mass of hay to the top layers.

5 Increased pressures are required to force air movement through increasing depths of hay. Fans generally deliver smaller quantities of air as the resistance to flow increases.

6 The combination of items 4 and 5 is such that the rate of drying at a 20-ft level may not be over one-third the rate at a 5-ft level. Great care must be exercised to prevent mold growth under slow drying conditions.

7 The data presented in this paper is not claimed to be absolute. Rather it is submitted on a qualitative basis recognizing the various factors involved and tempered somewhat by the hard knocks resulting from the experience of several investigations.

Training Agricultural Engineers to Meet Today's Challenge

By George B. Nutt
MEMBER A.S.A.E.

THE problems facing the agricultural engineering departments of land grant colleges and universities today are many and complex. Agricultural engineers, however, are noted for accepting challenges. We are told that the founders of our profession and of its national society faced antagonism in addition to encouragement. Did they give up because of difficulties? Emphatically, no! They took the facilities available and made the most of them.

I wish to repeat for historical background a part of the story found in the A.S.A.E. pamphlet "Agricultural Engineering as a Professional Career", as follows: "The American Society of Agricultural Engineers had its origin in December, 1907. The first degree of Bachelor of Science in Agricultural Engineering was conferred in 1910. By 1922 seven institutions were offering such training; in 1925, ten; in 1929, seventeen; in 1931, twenty." A recent memorandum from the office of the secretary of the Society lists twenty-seven land-grant colleges and universities that give instruction leading to the bachelor's degree in agricultural engineering or its equivalent. The founding fathers and all other members of the Society must take pride in this achievement. But we look back only to gain inspiration for facing problems of the present and of the future.

The college and universities training agricultural engineers form the backbone of the profession. Public agencies, industries, and all other classes of employers of agricultural engineers are dependent on these educational institutions for trained men. Before Pearl Harbor the twenty-seven institutions offering instruction leading toward the bachelor's degree in agricultural engineering were probably stronger than they are today. A high percentage of the faculty members answered the call to the colors or entered essential war industries. Others changed positions for various reasons. In many instances these men will not be returning to college work and replacing them is no simple matter. Because of low-salary scales in some institutions, it is difficult to interest well-trained, experienced men in teaching. Much of the equipment in the departments is out of date, and in some institutions buildings are wholly inadequate, even if other facilities were satisfactory. These conditions are mentioned merely to "lay the cards on the table" and understand the problem.

There is an unprecedented demand for agricultural engineering graduates. The Personnel Service Bulletin published in AGRICULTURAL ENGINEERING bears evidence to this effect. In a recent issue approximately fifty opportunities for employment were listed and described under "Positions Open". Many more positions become available and are filled that never appear in the Bulletin. Now that the war is over there will be many graduates available for these positions, but when these men who are being discharged from military service find employment, the supply will be practically exhausted for one or more years.

Employment possibilities are almost unlimited for agricultural engineers. Consider the technical divisions of the profession: farm power and machinery, farm structures, rural electrification, and soil and water conservation. The public and private agencies engaged in efforts related directly or indirectly to one or more of these fields are myriad. Most of these agencies have agricultural engineers on their staffs *and the others are beginning to realize their shortcomings.*

In the division of farm power and machinery, for example, agricultural engineers may engage in farming, merchandizing, teaching, research, design, manufacturing, advertising, promotion, sales and service. In the other three divisions opportunities for employment are equally as great and new fields are opening up rapidly.

Therefore, the training of additional men is a challenge. The colleges and universities must do the job, but they are going to need help. Assume that each of the twenty-seven institutions offering degree courses graduate fifteen students per year. Then they would graduate four hundred and five men. Surely we can employ that many each year in domestic positions, to say nothing of foreign positions. Undoubtedly there are many other colleges and universities that should offer instruction leading to the B.S.A.E. degree.

Much is expected today of the agricultural engineers in the colleges. Fortunately we are no longer looked upon as just grease-it-and-fix-it men. We are assuming positions of influence and leadership in the fields of resident and extension teaching and research. Teaching is by no means limited to the training of other agricultural engineers. Teaching students in vocational agriculture and general agriculture is an important phase of the program. Short courses, refresher courses and conferences are extending the areas of influence.

Intensified efforts toward the electrification of the nation's farms, conservation of farm land and further farm mechanization have opened up many positions for agricultural engineers and added prestige to the profession. College enrollment figures reflect the public interest in the field. At the present time at my own institution 25 per cent of our students in the agricultural college are agricultural engineers; in the past twelve years only one other department has graduated more students than has the agricultural engineering department. In this same period of time more than 5000 students have been enrolled for the service courses offered by the department, even though the service courses are offered primarily as electives. Many returning veterans are sacrificing credits earned in other fields to complete the requirements for a degree in agricultural engineering.

I repeat that many departments do not have the needed facilities to offer this training. It is not uncommon to find provisions for agricultural engineering below those of other departments. But agricultural engineering is comparatively a new field and it takes time and persistence to bring about needed improvements. It is not likely that ideal conditions will be provided in any institution for initiating a degree program. Therefore, we should urge other institutions to give instruction leading to the B.S.A.E. degree if only the minimum facilities are available.

If the demand for the services of agricultural engineers is to continue and if the profession is to gain in prestige, the standards for training must be maintained on a high plane. We are not likely to agree on a curriculum that will be exactly the same in all institutions. There are state and regional problems that should be considered. However, a graduate of any one of the *(Continued on page 130)*

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1945.

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A Forced Ventilation Hay Drier

By Andy T. Hendrix
MEMBER A.S.A.E.

THE drying of hay by forced ventilation has become an accepted and usual practice on many farms in Virginia and several other states. Despite the widespread acceptance of forced ventilation for supplementary drying of hay in the mow, agricultural engineers have recognized that the types of systems generally used were not as effective as they might be. However, fundamental information and data relative to performance factors of such drying systems were not adequate for use as a basis for improved design, and consequently little change has been made in the construction of such systems.

Because of the need for more data of an engineering nature the Division of Agricultural Engineering of the U.S. Department of Agriculture, in cooperation with the agricultural engineering department of the Virginia station, in the late summer of 1944 initiated limited experimental investigations to study the problem. The investigations were planned to obtain basic data on which more effective and simpler designs of forced-ventilation hay driers could be based.

Central Main-Duct-with-Laterals Type of Hay Drier. Various arrangements of duct systems have been devised for hay drying by forced ventilation. The type of drier which is in most general use in Virginia and the southeastern states is known as the central-main-duct-with-laterals system. This system consists of a low-pressure blower with a main air duct extending along the center of the mow floor and with smaller ducts, or laterals, extending outward from each side of the main duct as shown in Fig. 1. Results obtained by use of this type of drier have been very satisfactory. However, the system has some undesirable characteristics, and it has been generally felt that efforts to construct a drier for improved performance would be justified.

Static Pressures and Air Flow in a Main-Duct-with-Laterals System. The operating characteristics of forced ventilation hay driers have been well known. For experimental study of air distribution, air flow, and static pressures, a small, full-scale system of the main-duct-with-laterals type was constructed in accordance with recommendations most commonly followed in Virginia. This system was equipped with a variable-speed blower so that static pressure and volume-of-air flow could be controlled as desired.

Numerous observations were made of static pressures and air flow in this duct system under various conditions of system loading and fan discharge. Typical results obtained are indicated in Fig. 2. In the A portion of Fig. 2 curves are shown which indicate the relative distribution of air discharged from each side of a lateral duct.

In B of Fig. 2 are shown corresponding static pressure gradients as measured along the top inside center line of the lateral. In Fig. 2 the curves marked "a" indicate results obtained under conditions with no loading of hay or other external resistance on the lateral. The curves marked "b" show results obtained with an approximately uniform external resistance loading on the lateral. In both load and no-load conditions of the test, the volume of air flow was maintained at approximately that recommended for normal loaded conditions of operation.

In usual practice a one-inch crack for air outlet along each side of the lateral is recommended. It may be noted from the distribution curves "a" for no-load conditions that this one-inch crack has only a minor restricting or metering effect on the flow of air. Restriction to air flow in this type of system is primarily attained at the square-edged entrance from the main duct into the lateral. This is disclosed by the static pressure gradient line "a", Fig. 2, which shows that the entire static pressure within the main duct is required to effect the requisite velocity of air flow. The major portion of this static pressure is lost at the entrance to the lateral where it is partly converted into velocity pressure. As the air approaches the outer end of the lateral, the relatively high velocity pressure is partly converted into static pressure as regain. It is only this final static pressure which is available to effect flow of air out of the lateral and through the hay.

The rates of air flow under load and no-load condi-

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and reports results of a research project conducted by the Divisions of Agricultural Engineering, Bureau of Plant Industry Soils and Agricultural Engineering, U.S. Department of Agriculture, in cooperation with the agricultural engineering department of the Virginia Agricultural Experiment Station.

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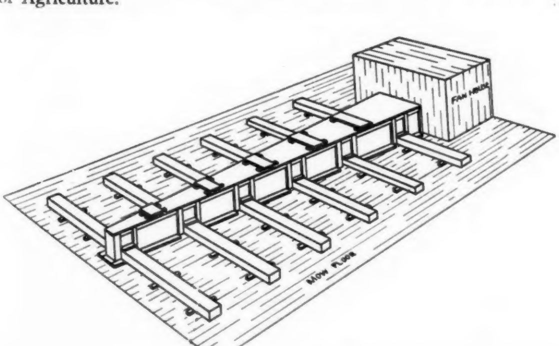

Fig. 1 This perspective drawing shows the conventional main-duct-with-laterals type of hay drier

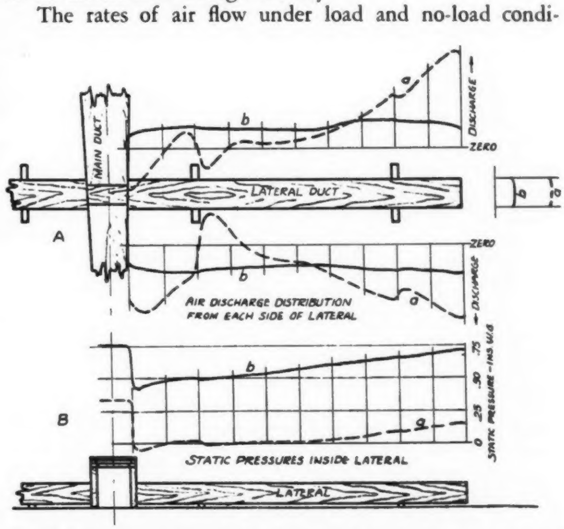

Fig. 2 Static pressures and distribution of air discharge in a lateral duct. Curves "a", no external load condition; curves "b", uniform external resistance

tions, Fig. 2, were kept approximately equal by varying the fan speed. The pressure losses in the main duct and lateral entrance should therefore be about the same in the two tests. This is indicated in B of Fig. 2 which shows the tendency of the static pressure curves to remain parallel.

Under conditions of external resistance to air flow from the lateral, the distribution of air discharge tends to be more nearly uniform than for no-load conditions. However, the same tendency toward higher static pressures and greater rate of air flow at the outer end of the lateral is evident. It will be noted that higher static pressure and air discharge occurs at the outer end of the lateral under a condition of very uniform external resistance than occurs near the inner end. Such a condition is seldom or never realized in actual drying of long hay in the mow. Observations of static pressures in laterals of driers in practical use disclosed conditions typically illustrated by Fig. 2.

Field observations of forced-ventilation driers have shown, in nearly every instance, that there is an excessive loss of air along the edges of the hay near the floor line. Also, the hay in the area of the mow along each side of the central main duct has been slowest to dry. The development of moldy hay has most frequently occurred in this section of the haymow. Test results shown graphically in Fig. 2 indicate that at least part of the difficulty in drying might be due to poor distribution of static pressures within the duct system. In the mow area near each side of the main duct there existed the lowest effective static pressures in the system. In this same area the hay is packed tightest while being placed in the mow. For equal rate of drying this condition would require higher static pressure in this area instead of lower pressure as was actually observed.

Modifications in main duct and lateral duct design, with subsequent observations of performance, showed that better air distribution could be obtained with less than half the usual static pressure loss in the main duct. When using a low-pressure type of fan the pressure obtained was adequate for effecting recommended air flow. The modified construction of the duct system was not adopted as a final satisfactory design because of the more difficult construction involved and because of other disadvantages.

Static Pressure and Air Flow Through Hay. Several observations under test conditions (as reported in part in the AGRICULTURAL ENGINEERING for September, 1945) were made to determine static pressures necessary to effect desired velocity of air flow through long hay in the mow. Results of these tests indicated that low-pressure fans could effect reasonably adequate rates of air flow through long hay. To accomplish this, pressure losses in the duct system must be kept as low as is reasonably possible. Since most low-pressure fans in use for hay drying usually operate most effectively against less than 1-in water gage pressure, the loss of from 1/4 to 1/2 in pressure in the duct system considerably affects the performance of the hay drier.

Design of a Hay Drier. With data and information obtained as a basis for design, a forced air system was planned with the following principal objectives:

1 To utilize a blower with non-overloading characteristics, and with a minimum reduction in volume with variations in external resistance.

2 To simplify construction of the main duct and other parts of the system so that an average rural carpenter could install the drier with a minimum of instruction and without special equipment.

3 To utilize commonly available materials in the construction of the system, thus lowering costs and facilitating installation.

4 To effect an increased rate of air flow per unit area

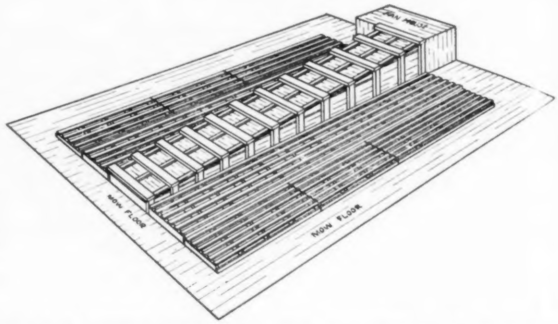

Fig. 3 Perspective view of the main-duct-and-slatted-floor type of hay drier. (Details of construction are shown in Figs. 4 and 5)

of mow floor by reducing duct losses to a reasonable and practical minimum.

5 To obtain improved air flow distribution through the hay by maintaining higher effective static pressures under the portion of the haymow along each side of the main duct, and by equalizing the resistance of the paths of air flow.

6 To reduce losses of air at the sides of the mow to a minimum practicable with increased rate of air flow per unit area of mow floor.

7 By accomplishing the foregoing, to effectively dry greater depths of hay within the same time period, or to more quickly dry equal depths of hay.

Blower and Drier System. Original recommendations for the design of hay driers specified a minimum volume of air of 8 1/3 cfm (cubic feet per minute) per square foot of mow floor area. This value for recommended rate of air flow was later increased to 10 cfm, and common practice has been to attempt to exceed even this higher value. Experimental studies and numerous observations of drier performance indicated that 10 cfm of air was fairly adequate so long as depth of hay per drying did not exceed approximately 6 ft, and if the moisture content of the hay when placed on the drier did not exceed 40 to 45 per cent. However, in actual drying practice both these values were often exceeded, with sometimes unsatisfactory results.

To overcome certain difficulties which had arisen, and which had become more pronounced as farmers' expectations of performance exceeded recommended practice, it was considered necessary to resort to greater volume of air flow than had previously been recommended. Increased volume of air could be obtained by increased static pressure under the hay. To achieve this increase in volume of air and the objectives listed above, the drier system, shown in Fig. 3, was designed. This system consists of a central tapering main duct which extends to within about 5 ft of each end of the mow space. On each side of this main duct is a slatted floor which is carried on joists resting on the mow floor. The joists are spaced at intervals of 24 in. Wide cracks at the mow floor level extend along each side of the

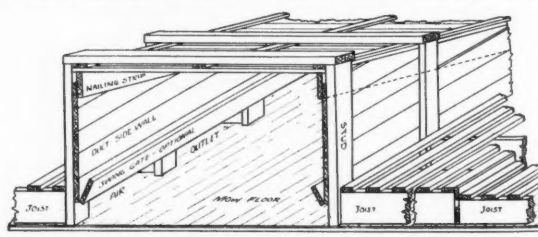

Fig. 4 Section of main duct floor of the drier shown in Fig. 3, showing construction details

main duct throughout its length. Air is forced from the main duct through these cracks and into the space under the slatted floor. The air then is forced between the slats of the slatted floor into and through the hay. The slatted floor in this instance extends to within about six feet of the edge of the effective mow space. Air is allowed relatively free passage from the blower to the point where it enters the hay through the open spaces in the slatted floor. The static pressure built up by the fan is thus utilized chiefly in effecting flow of air through the hay with a minimum of loss in the duct and laterals.

To supply the desired amount of air, a fan was selected which would provide approximately 20 cfm per sq ft of mow floor area against a static pressure of ¾ in water gage. At either free discharge or increase in static pressure the power requirement for operating the fan would not vary sufficiently to cause overloading of the motor unit. A static pressure of ¾ in water gage should, under reasonably good atmospheric conditions, permit satisfactory drying of long hay to depths of 12 ft or more.

Details of Main Duct. The cross-sectional size of the main duct is determined principally by two conflicting factors. Desirable medium velocity of air flow in the main duct requires that it be rather large in cross section. A smaller size is desirable to keep loss of hay storage space to a minimum, and to offer as little obstruction in the mow as possible. In general, the cross-sectional area of the main duct will be adequate if determined by the outlet dimensions of the blower. Velocity of air flow should be between 1500 and 2000 fpm (feet per minute) in the main duct under normal operating conditions.

Simplification of main duct construction for the plan shown in Fig. 3 was achieved by the design details shown in Fig. 4. Uniform width of main duct was maintained, with reduction in cross section being accomplished by reducing the height of the duct as distance from the blower increased. The principal objection heretofore offered to construction of a main duct of varying height was eliminated by providing support and nailing strips along the inside top edges of the sidewalls of the duct as shown in Fig. 4. No supporting members inside the duct are required except when a blower of the double-unit centrifugal type is used. This type blower requires a relatively wide and low main duct.

The necessity of providing separate square or rectangular openings for each lateral duct was eliminated by leaving a continuous crack at floor level along each side of the main duct. The size of this opening is determined by the conditions of each installation. The crack is of such width that velocity of flow maintained through the opening requires only low drop in pressure. High velocity of flow is avoided, and higher effective pressures can be made available under the hay. Losses are thus reduced to a minimum practicable for this class of construction. Caution should be used not to make this crack of unlimited size.

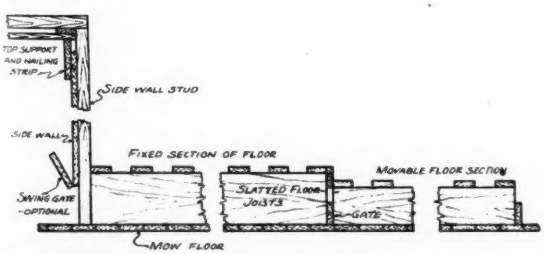

Fig. 5 Right half cross-section view of the duct and slatted floor of Fig. 3, showing the arrangement of fixed and movable slatted floor sections, with fixed gate for restricting air flow into the space under the movable section of slatted floor

The same method heretofore used for air outlets on top of the main duct was retained, but the number of such outlets was increased.

The Slatted Floor. A slatted floor was used in this design because it offered a simple, easily constructed support for the hay and at the same time permitted entry of air into the hay with relatively low loss of pressure. Width of slats used was such that the entire weight of a man would be sustained by one slat between two supporting joists. Slats 1 × 3 in, rough sawed, were found to be satisfactory for this purpose. These slats were placed 6 in on centers, leaving a 3-in space between slats. It was found that a surprisingly small quantity of hay material fell through these cracks onto the floor, although provision for cleaning the floor was made in planning the system. When the system is unloaded the spaces under the floor can be cleaned without difficulty when cleaning is necessary.

The distance which the slatted floor extends outward from the main duct is dependent on the width of the mow, the height of the side walls, and the depth of hay to be dried. Under most circumstances extension of the slatted floor to within six feet or more of the side of the effective mow space will probably be adequate. In narrow mow spaces the slatted floor on each side of the main duct probably should be eliminated, and only a slatted main duct used. In such instances the top construction of the main duct may be as shown, while the sidewalls may be of spaced slat construction to permit ready egress of air from the duct into the hay. Where it is feasible and reasonably economical to make smooth vertical walls for the sides of the mow, the slatted floor can be extended closer to the sidewalls. In such cases the hay should be carefully packed against the walls by tramping.

One of the greatest difficulties encountered in drying hay by the forced-ventilation system has been the loss of air at the sides and edges of the hay near floor level. As the depth of hay becomes greater, this air loss at the sides constitutes a greater portion of the total air flow than it does in lesser hay depths. To minimize this difficulty — and for other reasons — the slatted floor on each side of the main duct was constructed in two parts as shown in Fig. 5. The portion of floor next to the duct was fixed, with joists fastened to the main duct sidewall studs and also to the floor. The joists thus served as supports for the slatted floor and as brace members for the sidewalls of the main duct. Outside the fixed portion of the slatted floor, sections of slatted floor were placed loosely on the floor of the mow. These outer sections of floor are of lower height than the part of the floor nearest the duct. Each unattached outer section is of such size that it can be readily moved by one man for cleaning underneath it and the adjoining part of the fixed slatted floor.

Between the fixed and loose parts of the slatted floor, gates are provided as shown in Fig. 5. These gates, which are either fixed or adjustable, serve to restrict the flow of air into the space under the outer loose sections of floor. It is this feature of the design which we think contributes appreciably to better system performance by maintaining higher static pressure under the hay in the areas on each side of the main duct, and by reducing the loss of air at the sides of the mow. Better flow of air through the hay is thus effected, and more drying realized. Proper selection of the size of gate opening between the sections of the floor will maintain relatively high pressure under that part of the floor near the duct, while the pressure of air under the outer portion can be reduced as desired. This will result in greater air flow through the hay in the center of the

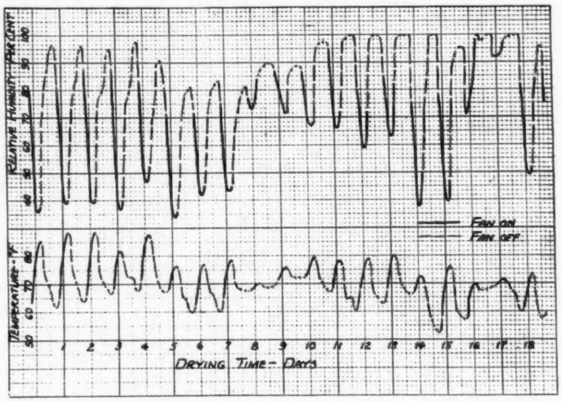

Fig. 6 This graph shows temperature and relative humidity of ambient air during the drying period

mow, with consequently less air losses at the outer edges. It will also permit more effective drying of greater depths of hay.

The width of the air-outlet openings in the sides of the main duct is so planned that excessive losses are prevented should a portion of the mow offer low resistance to the flow of air. Each space between joists serves somewhat as a duct which is separated from the adjoining duct space by a supporting joist. The air outlet into each space between joists is adequate for normal flow of air with only low loss of pressure. It is, however, insufficient in size to permit more than two to three times normal rate of flow under a condition of usual system operating pressure and free discharge. Such a condition could hardly exist in a reasonably well-managed installation.

Results, Test 1. The forced-ventilation system as described in the foregoing paragraphs was installed in a barn at the Virginia Agricultural Experiment Station in 1945 for trial. Installation was completed late in the season in time for drying the third cutting of alfalfa. The fan used was a vane-type axial flow fan, driven by a V-belt drive from an electric motor. The mow floor area was 40 ft wide by 50 ft long.

The alfalfa as cut was in full-bloom stage and was of good quality. Cutting was started on August 27 at 9:00 a.m., and proceeded intermittently until completed. The hay was cut down and allowed to remain in the swath for periods ranging from a few minutes to as much as one day, depending on conditions. The hay was loaded directly from the swath and placed on the drier immediately. Four days were required to place 52 loads of alfalfa on the drier. Moisture content of the hay ranged from a high value of 68 per cent to a low value of 24 per cent with a mean value — assuming equal-size loads — of 46 per cent for the entire 52 loads of alfalfa.

As soon as the alfalfa was placed on the drier, hauling of soybeans was started. Nine loads of soybean hay were placed on top of the alfalfa. The moisture content of the soybeans varied from 49 to 36 per cent, with a mean moisture content of 41 per cent. Loading of the drier was completed at noon September 4 with hay 14 ft in depth.

Operating Schedule of Fan. The fan was started at 1:30 p.m., August 27, and was operated on a daily schedule as recommended for Virginia conditions. This schedule was: On, 8:00 a.m.; off, 9:00 p.m.; on, 12 m; off, 1:00 a.m.; on, 4:00 a.m.; off, 5:00 a.m.

After drying, the 14-ft depth of hay had settled to approximately 11 ft. Using an estimated value of 400 cu ft of dry hay per ton, 49 tons of hay were dried to a moisture content of less than 20 per cent. The total power consumption, including the power required for hoisting the hay, was 1830 kw-hr. The time required for the drying was 18 days. This included the time required for placing the hay on the drier.

Atmospheric conditions of temperature and humidity which prevailed during the drying period are shown in Fig. 6. The solid portion of the curve shows the total time during which the blower was in operation. As will be noticed by examination of this graph, a schedule to obtain more drying effect without increasing operating hours per day would be obtained by delaying the daily time of starting the operation period by at least one hour. In that way the mean relative humidity during the drying period would be lowered and the mean temperature would be raised.

Static Pressures Under Slatted Floor. During the drying period several observations were made of the slatted floor system operating characteristics. In Fig. 7 are shown comparisons of static pressures recorded under similar conditions of operation for slatted-floor types of driers and a duct-and-lateral type of system. In "A" of Fig. 7 are shown static pressures as recorded in and near a lateral of a drier of the type shown in Fig. 1. These pressures were observed with a load of approximately 14 ft of hay on the system. In "B" of Fig. 7 are shown static pressures recorded under a slatted floor without a restricting gate, while "C" of Fig. 7 shows static pressures recorded in a system such as is illustrated in Figs. 3, 4, and 5. Under conditions of "C" of Fig. 7 there was a noticeable reduction in quantity of air flow out the sides of the hay near the mow floor.

The quality of the hay obtained by this trial was considered excellent although it was not officially graded for quality. No mold has been observed at any point in the hay.

SUMMARY

The central duct system for hay driers is not new. Neither is the use of a slatted floor. However, the plan presented here has some features which have not heretofore been used in general practice. (*Continued on page 120*)

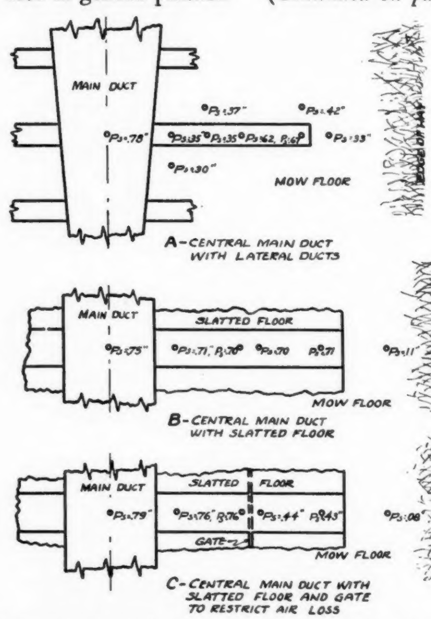

Fig. 7 A comparison of static pressures at mow floor level in three hay driers. P_s = static pressure in inches of water

Factors Affecting the Nutritional Value of Forage Plants

By H. A. MacDonald

THERE is at the present time a greatly increased interest in forage plants, their production, curing and storage. With this in mind it may be well to review briefly some of the factors affecting the nutritional value of such plants when produced for hay.

No single crop enterprise is more widely adapted or used throughout this country, or the world, than is that of forage crops. More people are dependent, fully or in part, upon forage crop production than upon any other crop. Forage is the very basis for a large part of our livestock and allied industries. It has been estimated that the hay crop alone has an annual farm value of approximately seven hundred million dollars.[16]*

The hay crop comprises a variety of plant species grown under a wide range of conditions of soil, climate, and topography, and handled in various ways. A crop may be harvested for one, two or several years from the same seeding. Similarly there may be one or several cuttings taken in any single year. For these and other reasons there is probably a greater variation in the quality of hay than in any other feed crop harvested on our farms. For the same reasons the overcoming of these variations with the object of producing a uniform high-quality forage is a matter of great difficulty and concern. It has been estimated that the United States farmer is recovering not more than 75 per cent of the value of the hay crop produced due to difficulties and lack of efficiency in harvesting, curing, handling and storage practices.[16]

Hay quality as referred to in this paper means nutritional or feed value. The nutritional value of hay is reflected in a number of physical factors which can be easily ranked for practical use. These factors of quality, as used in the grading of hay, include in addition to the hay class (1) stage of maturity when cut, (2) percentage of leaves, (3) percentage of green color, (4) percentage of foreign material, (5) condition as to soundness, (6) coarseness or size of stems, and (7) aroma.

While these physical factors are related to, and generally go along with, the nutritional value of the hay, they can be used only as a general guide. Nutritional value from a feeding point of view is best measured by the digestibility of the forage and its protein, carbohydrate, mineral and vitamin content.

The composition of any hay and its nutritional value, at a given stage of maturity, is largely dependent upon the plant species present. The great bulk of our forage harvested for hay is made up of grasses and legumes, grown singly or in mixtures of varying proportions. Legume hay has, normally, a higher protein, calcium, and phosphorous content than does grass hay. Under most conditions, mixed grass-legume hay is lower in nutritive value than a pure legume hay but higher than a pure grass hay. This is true, however, only where the species in the mixtures are compatable in relation to habit of growth, stage of maturity and related factors. While legumes are usually higher than grasses in nutritive value, it should not be overlooked that legumes are subject to many more hazards resulting in nutritional losses than grasses. For this reason it becomes increasingly necessary that great care be taken in the handling of such crops. Due to poor adaptation or limited survival a greater production of total digestible nutrients is produced on many farms by the use of mixtures than would otherwise be the case. Table 1 compiled from data by Morrison[14] shows a comparison of the nutrient composition of some of the most important hay grasses and legumes.

TABLE 1. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF SOME COMMON FORAGE CROPS FOR HAY
(Adapted from Morrison[14])

Forage material	Per cent of dry matter: Protein	Fat	Fiber	N-free extract	Ash	Digestible protein per cent	Total digestible nutrients per cent
Alfalfa in bloom	14.0	2.0	30.3	35.8	8.3	9.9	49.7
Red clover in bloom	12.6	3.6	26.2	39.6	6.2	7.2	53.4
Alsike in bloom	13.4	3.2	26.9	37.7	7.8	8.6	52.7
Timothy in bloom	6.2	2.6	30.3	44.8	4.8	3.2	48.0
Brome grass	9.9	2.1	28.4	39.5	8.2	5.0	48.9
Oat hay	8.3	2.7	28.4	41.7	6.9	4.5	46.3

In general, the stage of growth or development of the herbage when cut and the method of curing have more influence upon the feeding value of the resulting hay than the species or variety of plant contained in the hay. The stage of growth has a very marked influence on the gross yield of hay and its nutritive composition. The palatability and digestibility of the forage is also greatly influenced by the time of cutting. The hazards of weather and the time and labor-consuming nature of haymaking practices now in use are perhaps the greatest factors controlling the time of hay harvest.

The yield of most perennial herbage plants increases rapidly during the early stages of growth, is fairly constant during the flowering period, and declines thereafter. In the case of annual and biennial plants the decline following flowering is much less marked.

As the growth of hay plants advances toward maturity, the percentage of protein decreases while the percentage of fiber increases. There is a decline in the percentage of ash and its constituents. The trend and relative magnitude of these changes is shown in Tables 2 and 3. Similar results are reported for red clover, alsike clover and many other forage plants.

TABLE 2. EFFECT OF TIME OF CUTTING UPON THE CHEMICAL COMPOSITION OF ALFALFA HAY
(From Kiesselbach and Anderson[11])

Stage of maturity	Protein, per cent	Fat, per cent	Nitrogen-free extract, per cent	Fiber, per cent	Ash, per cent
Prebloom	21.98	2.93	38.72	25.13	11.24
Initial bloom	20.03	3.03	40.67	25.75	10.52
One-tenth bloom	19.24	3.02	40.38	27.09	10.27
One-half bloom	18.84	2.90	39.45	28.12	10.69
Full bloom	18.13	2.99	38.70	30.82	9.36
Seed stage	14.06	2.39	39.61	36.61	7.33

TABLE 3. EFFECT OF TIME OF CUTTING UPON THE CHEMICAL COMPOSITION OF TIMOTHY HAY
(From Trowbridge, Haigh, and Moulton[20])

Stage of maturity	Protein, per cent	Fat, per cent	Nitrogen-free extract, per cent	Fiber, per cent	Ash, per cent
No heads showing (1 ft.)	10.18	4.61	50.49	26.31	8.41
Beginning to head	8.02	4.07	49.14	31.15	7.61
Full bloom	5.90	2.38	51.89	33.74	6.10
Past bloom	5.27	3.13	54.12	31.95	5.54
Seed all in dough	5.06	2.87	56.48	30.21	5.38
Seed fully ripe	5.12	2.72	55.87	31.07	5.23

A paper presented at the barn hay-curing conference sponsored by the American Society of Agricultural Engineers at Purdue University, West Lafayette, Ind., January, 1946.

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*Superscript numbers refer to appended references.

Several changes occurring with advancing maturity contribute to the decline in nutrient value. The change in the leaf to stem ratio is perhaps the greatest contributing factor in legumes. Changes in the leaf percentage of alfalfa from 57.3 to 33.3 with advancing maturity has been reported[11] in Nebraska. This did not include losses occurring in curing. The greatest leaf loss occurs in the later stages of growth following full bloom. Such losses may be brought about by several causes such as disease, insect injury, adverse weather conditions, lodging, and natural leaf shedding with maturity. The leaves of forage crops are much superior to the stems in nutritional value due to their higher percentage of valuable constituents and being lower in the amount of less digestible fiber. It has been shown that alfalfa leaves are roughly twice as high in percentage protein as the stems of the same plant, while the stems have a crude fiber content about three times that of the leaves[23].

The change in nutritional composition of forage legumes with advancing maturity cannot be attributed entirely to the change in the ratio of leaves to stems. The composition of the leaves and stems themselves change with age as is shown in Table 4. The change is much more rapid in the stems than in the leaves. In an investigation at Cornell University the protein content of Ladino white clover leaves changed from 31.8 to 11.3 per cent in seven weeks. During the same period the phosphorous content changed from 0.56 to 0.11 per cent with advancing age. Similar changes were observed in other constituents.

TABLE 4. PERCENTAGE OF LEAVES OF ALFALFA AND TIMOTHY AND THEIR CHANGE IN COMPOSITION AT DIFFERENT STAGES OF GROWTH

	Proportion	Leaf		Stem	
Stage of growth	of total weight, per cent	Protein, per cent	Crude Fiber, per cent	Protein, per cent	Crude Fiber, per cent
		Alfalfa[23]			
Prebudding stage	58.5	32.83	12.47	19.46	30.94
Budding stage	48.4	28.38	13.19	13.57	42.88
Early flowering stage	42.1	24.57	13.94	11.03	46.49
		Timothy[10]			
Headed	38.2	11.6	24.3	4.4	33.8
Early bloom	29.3	11.6	25.1	4.8	39.7
Just past full bloom	20.5	11.0	25.0	3.2	40.7
10 per cent of heads straw colored	11.5	9.0	25.0	2.9	43.0
Heads mature	10.0	6.6	25.9	2.8	41.6

In the case of the grasses, the leaf loss is usually not great. Although the leaves may remain attached to the plant till maturity, there is, however, a very great decline in the nutrient content of these organs, and of the entire plant, with age. Many grasses which are palatable and nutritious at the early stages of growth become almost worthless as feed upon reaching maturity.

Much interest is now being directed to the carotene content of forage crops, since this is an important source of vitamin A for animals and man. A study of the carotene content has been included in many recent forage investigations. Briefly these studies have shown the following results: (1) The carotene content of young plants is high. (2) It decreases with plant development and growth. (3) The leaves are higher in carotene than are the stems and thus leaf loss results in a reduction in the carotene concentration in the crops. (4) There is more difference in the carotene content of different plant species than of various strains of the same species. (5) Legumes are usually higher in carotene content than are the grasses. (6) When a crop is maintained in a vegetation condition, by frequent grazing or clipping, the carotene content remains at a relatively high level. (7) There is often a decline in the carotene content of pasture herbage in midsummer when the plants suffer from drought and when there is a reduction in vegetative growth. (8) There is usually a good correlation between the carotene and protein content of forage plants when in the green growing condition. However, protein is much more stable and may be maintained under conditions which result in a marked reduction of carotene. (9) Fertilization has little effect on the carotene content of forage crops, except where such treatment changes the botanical composition of the crop or its leaf-stem ratio. (10) Extensive carotene losses occur during the curing and storage of forage crops. In silage it is relatively well maintained.

Under normal haymaking procedures there is always a loss in nutritional value. This reduction, depending upon weather and other conditions, may be only slight or may be as high as 30 to 40 per cent. It may result in the loss of the entire crop. There are perhaps three major sources of nutrient loss in normal field curing. These may be listed as (1) normal respiration loss, (2) weathering losses including leaching, and (3) mechanical losses including leaf loss.

Perhaps the loss of carotene occurs more rapidly than that of any other nutrient. It has been reported that up to 65 per cent of the carotene may be lost in as little as 30 hr of normal field exposure[24]. To restrict this carotene loss it is necessary to bring the hay to an air-dry condition in the shortest possible time. A number of recent investigations have shown a fair correlation between the loss of green color in hay and the loss of carotene.

Other nutrients, in addition to carotene, are lost in large amounts during hay curing. As the plant cells continue to live for some time after cutting, respiration continues with an accompanying loss of dry matter. Recent investigations have shown losses of from 3.0 to 5.0 per cent during normal curing practice.

The losses due to normal respiration in the field are largely controlled by the rate and efficiency of drying. Loss of dry matter due to this cause is reported to range from 3 to 13 per cent of the total dry matter[5]. Respiration losses have not been extensively studied up to this time.

The greatest and most unpredictable loss occurring in the curing of hay may be attributed to unfavorable weather. Under conditions of excessive or frequent rain and high humidity losses due to secondary respiration, fermentation, bacterial action and leaching may be very great. A reduction in the nutritional value or the loss of the entire crop may occur. It is difficult to evaluate these losses since the extent to which they occur depends so much upon the type of material and its condition when exposed to varying unfavorable conditions. In general, the dryer the material has become prior to being subjected to adverse weather, the greater is the damage done. It is the most valuable plant constituents that are lost under these conditions, the protein, carbohydrates and soluble minerals being the most readily lost. California research workers[6] report leaching losses amounting to 67 per cent of the minerals, 35 per cent of the carbohydrates, and 18 per cent of the protein.

Studies in Kansas[17] report leaf losses during curing of from 2.3 to 34.0 per cent, this being from 1.2 to 17.4 per cent of the total crop and a proportional larger part of its nutrient content. These data compare well with those of many other workers. A loss of alfalfa leaves during curing exceeding 30 per cent is commonly reported. The mechanical loss of stems, grass leaves, seeds, and other plant parts occur to a lesser extent but at times become a serious source of loss of forage nutrients.

Recent investigations at Cornell University have shown losses during the curing and storage of alfalfa hay as follows:

Leaf loss before harvest	5.1	per cent of dry matter yield
Leaf loss during harvest	0.9	" "
Leaf loss in curing	13.3	" "
Respiration loss in curing	7.2	" "
Loss in storage (5 mo.)	4.9	" "
Total loss	31.4	" "

This loss of 31.4 per cent of the total dry matter produced represents the most nutritious parts and constituents of the crop. For instance, this loss represented 40.9 per cent of the total protein produced.

A considerable part of the spoilage occurring in hay during curing may be attributed, not to excessive moisture content as such but to the nature of the crops material and its influence upon the ease of removal of the contained moisture. Succulent forage such as early cut red clover, Ladino white clover and leafy immature grasses which become limp upon wilting present a real problem both in field and barn curing. Forage of this nature is likely to form a mat, or compressed mass of material, in the field or barn-curing system. This may become so impervious that proper aeration of the mass is difficult if not almost impossible. For this reason, in the use of any system of hay curing, the nature of the forage material, to be worked with, must be known and fully appreciated if the curing system is to give maximum efficiency.

For many years it was thought that there was little if any change in nutritional value during the storage of hay. Many investigations relative to the shrinkage of hay in the stack or storage were conducted between 1890 and 1920. Shrinkage in most instances was attributed to the loss of moisture only. In 1920 one investigator stated that "the loss is practically of water only—there is practically no loss of dry or nutrient matter during the shrinkage of hay while in the barn or stack"[13].

Changes in stored hay, which affect market quality or grade, are usually quite obvious to those who feed or handle hay. Such apparent changes include change in color, in physical condition, aroma and palatability. Many serious, although less recognized, underlying changes and losses of hay quality occur however. These include losses in quantity and quality of dry matter, protein, and vitamins, and reduction in digestibility. These changes are markedly affected by the type of forage material, its curing, and condition of storage.

When hay having an excessive moisture content is stored in this condition, the loss may be very great. Frequently not only the entire hay crop is destroyed but the loss of other stored crops, farm buildings, equipment, and livestock may result from spontaneous combustion of the hay. It has been estimated that farm losses amounting to $20 million occur annually from this cause alone[12]. It is generally considered that there is little danger of spontaneous combustion of hay when the moisture content of the stored forage is below 30 per cent and when it does not exceed this amount during storage. The nature and cause of the changes taking place in undercured hay which result in spontaneous combustion are not thoroughly understood. The various theories advanced have been reviewed by Browne[2] and Henson[7] and will not be discussed here. However, when the amount of energy required to raise the temperature of a large stack or mow of hay and maintain this high temperature for periods of time is considered, it becomes evident that there is a very large loss even before combustion takes place or when actual combustion does not result.

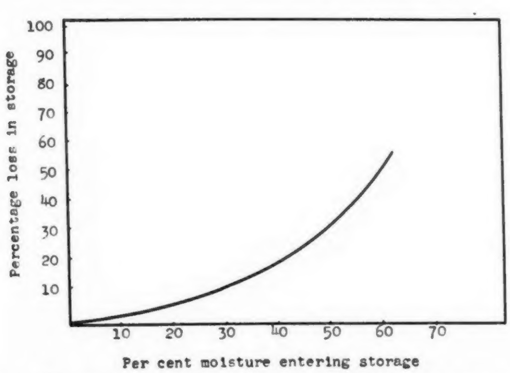

Fig. 1 Relationship of moisture content of hay entering storage to dry matter losses in storage. Summary of varying conditions computed to six months' storage period

The loss of nutrients by spontaneous combustion is small in comparison with the greater, although much less obvious, losses occurring in storage. Until recently these losses were considered insignificant. However, it is now fully apparent that under certain conditions there may be dry matter and nutrient losses in large amounts.

When spontaneous heating without combustion takes place, the loss of nutrients may be very great. Swanson and his associates[18] found the dry matter loss in the production of brown and black alfalfa hay to be as much as 39 per cent. A loss of 45 per cent of the nitrogen-free extract and 33 per cent of the protein was found. A destruction of 22 per cent of the dry matter in the production of brown hay from alfalfa was found by Hoffman and Bradshaw[9]. In storage heating it is the more digestible and most nutritious materials which are affected to the greatest extent resulting in a product of greatly reduced feeding value.

Recently Bechtel and co-workers[1] studied normal, brown, and black hay. No information was available to indicate nutritive changes in comparison with the originally stacked hay, changes in the composition of the brown and black hays in comparison with the normal sample were, however, significant as is indicated in Table 5.

TABLE 5. CHEMICAL COMPOSITION AND TOTAL DIGESTIBLE NUTRIENTS OF NORMAL, BROWN AND BLACK HAY
(From Bechtel, Shaw and Atkinson[1])

	Composition of dry matter, per cent					Total
Material	Crude protein	Ether extract	N-free extract	Crude fiber	Ash	digestible nutrients, per cent
Normal hay	21.51	2.40	41.16	25.20	9.72	55.70
Brown hay	21.04	1.93	38.27	28.17	10.60	37.50
Black hay	21.03	1.85	30.42	35.03	11.66	23.40

Many authors report a decrease in the palatability and digestibility of black hay as might be expected. Brown or fermented hay may maintain a high level of palatability although having a great loss of nutrients. This has been reported by Henson[7] and Willard[22]. Brown hay is, of course, little different from a form of grass or hay silage.

In the case of normal, well-cured hay, which has entered storage at less than 30 per cent moisture, the losses during storage are greatly reduced. Changes and losses do occur, however. These are largely controlled by the condition of the hay, the storage facilities and the weather or atmosphere. These losses are greater in a moist than in a dry climate. Storage of hay on a moist or a ground floor results in much greater depreciation than is generally realized.

Various workers have reported losses of dry matter and nutrients occurring in hay stored under normal condi-

tions. Woodward and Shepard[25] report losses of from 3.5 to 4.1 per cent in hay after three months storage at 25 to 27 per cent moisture. Camburn and co-workers[3,4] found very similar results working with alfalfa hay. Hodgson[8] and others working under more humid conditions in Washington found dry matter losses ranging from 8.9 to 12.9 per cent when grass and clover hay was stored at 27 per cent moisture. Other workers report similar losses. The relation of moisture content of stored hay to the dry matter loss in storage is presented graphically in Fig. 1. It cannot be considered that this relationship will apply to any one set of conditions since it is merely a summary of reports from a wide range of conditions. A detailed study relating to this subject is needed.

The reduction in yield and nutritional value of "at the manger" hay caused by changes and losses occurring during the handling, processing, and feeding of hay other than curing and storage, has not been thoroughly investigated. These losses are in many cases considerable. Many handling and processing operations result in very great loss of the most valuable part of the forage. There is need for further investigation and improvement of such operations. Attention may well be further directed to these problems and their solution with the increased emphasis now being given to hay and haymaking procedures.

For many years large sums have been spent in conducting investigations into ways and means of improving the yield and nutritive value of forage for feed for livestock. In the field of agronomy, the greatest emphasis has been placed on plant improvement through selection and breeding, and on cultural advances through soil improvement, fertilization and so-called management practices. Admittedly these two fields of work have contributed much and will continue to contribute to a higher production of a more nutritious forage. However, it has now been well demonstrated that in many cases not more than 80 per cent and often as low as only 60 per cent of the produced forage has reached the animal for consumption. This loss of from 20 to 40 per cent of the maximum crop produced represents the most nutritious part of the forage which makes the loss in terms of digestible nutrients even greater than that indicated. In few other agricultural crops are losses of this magnitude experienced.

The difficulty of curing hay plants at their most nutritious stage of growth, without excessive loss, and the problem of maintaining their high nutritional value during handling and storage is one of the greatest problems facing us today in the field of forage production. It would seem therefore that, at the present time, greater advances can be made in this field through the development of improved ways and methods of handling forage efficiently than by any other means.

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A Forced Ventilation Hay Drier

(Continued from page 116)

The system is simple in construction, does not require high quality or dressed lumber, and offers good air distribution with low pressure loss in the system. Performance and results have been very satisfactory in the experimental trial. Slatted-floor installations in use during the 1945 season by several farmers have given reasonably satisfactory results.

Over-all performance of a forced-ventilation system for hay drying is rather difficult to measure in a manner which permits satisfactory comparison with other driers under different conditions. Whether or not the plan herein described is superior to other systems in use is a matter yet to be determined. It is thought that this plan has features which give it definite advantages over other similar systems now in use, and eliminates or reduces most of the disadvantages present in other systems.

The above-described plan for a forced-ventilation hay drier system is presented for consideration and critical analysis by those engaged or interested in hay drying work.

NOTE: Detailed instructions for the design of a slatted-floor system for forced ventilation supplementary drying of hay may be obtained from the Agricultural Engineering Department, Virginia Polytechnic Institute, Blacksburg, Va.

Calculating Fan, Motor, and Duct Requirements

By George R. Shier
MEMBER A.S.A.E.

TO BEGIN with I will assume, following the technique established by other speakers, that it has been determined that 24,000 cfm (cubic feet per minute) at 1 in of static pressure is required for a mow 40x40 ft and that the electric power line is capable of handling up to 7½ hp single phase.

A brief study of manufacturers' catalogs will establish the fact that the required volume of air can be achieved with one fan within the power limit. Further, it will be observed that either centrifugal or axial flow fans can be used.

If the low-speed type of centrifugal or axial-flow fan is considered, it would be necessary to provide means to adjust the speed of the fan, or to control the static pressure, to avoid overloading the motor. It would also be necessary to provide an ammeter to show when the motor was properly loaded. These devices make it possible to use the low-speed type of fan, but they complicate the management and increase the risk of damage and inferior performance. The ideal type of equipment for ventilating hay should be such that the only control necessary by the operator is the starting and stopping of the motor. It can then be safely operated by any responsible member of the farm family.

In actual practice the farm customer may select the manufacturer of his equipment, but he will depend upon a competent dealer or rural service man for the size and design of equipment and distribution system.

The group upon whom the responsibility falls for the general design, including the selection of fan, drive, motor and distribution system, is this group to which I am speaking. For the most part, each job is different from all other jobs. It would seem that a standard design and layout could be used that would fit the majority of cases, but actual experience has not proved it practical. However, parts of the system can be standardized. For example, there are only six sizes of integral horsepower motors between 1 and 7½ hp at standard motor speeds. At once this limits the selection of the fan to six principal sizes, one for each of the motor sizes. This makes the dealer's problem simpler in that he need stock only a few sizes of fans.

Aside from selection of a fan to fit the capacity needed, it is important that the fan be one that is easy to maintain. It must be rugged and designed to operate continuously at full load for periods of two weeks or more. The bearings are especially important. Failure of a bearing may cause stoppage at a critical time and occasion serious damage to the hay. It seems fair to require that the bearings be of the highest quality and securely sealed to prevent loss of lubricant and entrance of air. During the winter and spring, the fan is idle and inexpensive bearings may corrode enough to occasion trouble later on if they are not properly sealed against moisture, oxygen and fumes. Good bearings need attention only once each season and will serve for many years. The same considerations apply to motor bearings. In the case of certain makes of motors, they are available with sealed bearings that require lubrication only after several years of service. To be lubricated the motor must be dismembered, but this does have advantages for farm use.

This paper was presented at the barn hay-curing conference sponsored by the Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946.

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There is a good rule of thumb that can be used in fan selection. It can be applied to most of the fans that will be used for ventilating hay.

The fan outlet can be readily measured and the outlet should provide at least one square foot for each 2500 cfm at ½-in static pressure and at least one square foot for each 2000 cfm at 1-in static pressure. More air can be forced through fans than this would indicate, but it usually requires excessive power. Somewhat slower outlet velocities are usually more efficient in the use of power.

Applying this rule of thumb to our need for 24,000 cfm at 1-in static pressure, the result is 12 sq ft. In either centrifugal or axial-flow fans this would mean a 48-in wheel.

The only other fan selection problem that might arise would be the space into which the fan is to be fitted and the weight to be supported. Because the over-all dimensions of axial-flow fans are less than those of centrifugal fans, they have an inherent advantage in handling, transportation, and the use of space.

It might be well to mention the drive briefly. Fans which operate at standard motor speeds can be direct connected, but most customers seem to prefer belt-driven fans which provide flexibility in the use of the motor. V belts will generally be used because they are not subject to dislocation and breakage to the same extent as flat belts. The selection of the proper size of pulleys and belts is simple, and most dealers can do it if they acquaint themselves with the selection tables provided by the drive manufacturers. There are a few things to keep in mind. Standard V-belt pulleys are made to fit shafts up to 1⅝-in diameter in the sizes generally used on motors. Consequently the cost of the drive increases sharply if a special pulley has to be made to fit larger sizes of motor shafts. The standard N.E.M.A. 7½-hp, single-phase motor frame has a 1⅝-in shaft, but occasionally non-standard frames with oversize shafts will be encountered, especially in older single-phase motors of 7½ hp.

In the past, few single-phase motors of 5 and 7½ hp were manufactured. The ventilation of hay is the first rural process to develop that requires an extensive use of these sizes of motors.

Because larger power units have not been common, the size of motor may be limited by the capacity of the rural service line, and if that be the case, it is desirable to select a motor that will start at low voltage. Repulsion motors have an advantage in this respect, and at present most 5 and 7½-hp motors are repulsion starts, but considerable progress has been made in the design of capacitor-start motors that will get up to speed at low voltage, and it seems probable that most of the motors in the future will be of this type.

The capacitor-start motor somewhat resembles the 3-phase motor in construction, and consequently can be rapidly assembled with far less hand labor than is required for the repulsion-start motor. It has no brushes and consequently no arcing to create radio interference and to burn the brushes. The chief disadvantage of the capacitor-start motor has been the large volume of current consumption on the start. On a weak line this pulled the voltage down and prevented the motor from coming up to speed. Some improvement has been achieved by reducing the torque, and consequently lengthening the start, and it seems probable that the capacitor-start motor will be the dominant type.

However, aside from arcing and radio interference, there is nothing from the consumer standpoint against the repulsion-start motor. It does a good job, and under poor conditions will start if any type of motor will get under way.

The high-speed types of fans start easily, and there is little load on the motor until the fan has been brought up to speed.

It is usually the starting load that causes trouble on low-voltage lines. In many cases it may be an advantage to use two smaller fans. Two 5-hp fans can often be used on the same line where one 7½-hp motor would fail to start.

Air Ducts. The design of the distribution system is determined by a few simple rules plus a large amount of experience and local detail. Knowing the volume of air to be moved, it is easy to apply a formula to determine the size of the ducts and outlet openings. Of more importance is the background of experience that gives the designer confidence that he is able to apply not just a formula, but a formula that will work.

Few layouts will be identical. There are always a number of factors such as posts, braces, width-depth ratios, hay chutes, stairways, water tanks, grain bins, barn floors, entrances and adjoining sheds that control the arrangement. Perhaps there are mows that will take identical designs, but in my own experience this has happened only once. In the case in question, a farmer had two barns exactly alike and the two designs could be prepared as one plan.

The first problem in preparing a design is to view the mow and obtain accurate measurements, together with notes on the method by which the hay is to be placed in the mow and removed. Considerable thought must be given to the effect of the design upon the labor of removing and feeding the hay, and the system must be arranged accordingly. There is no reason why the layout should necessarily follow a preconceived idea as to the location and size of the main duct. Whether the main duct will be divided, placed on the side or in the center are matters of convenience, not fundamentals of engineering formula.

THE PRINCIPAL QUESTION IN REGARD TO THE MAIN DUCT IS VELOCITY OF THE AIR

The principal question in regard to the main duct is the velocity of the air. Velocities of 1000 fpm (feet per minute) or less are easy to control. The pressure distributes rather evenly throughout the length of the duct as in a plenum chamber. Uniform pressure in the main duct usually provides uniform entrance velocities into the laterals.

Some of the earlier systems were designed to operate at higher main duct velocities around 1600 fpm. There are some advantages to higher velocities, in the reduction of cross section and the amount of material required, but more attention must be paid to the condition of the surfaces along which the air flows and to the inlet openings. Tests made by Hendrix have resulted in recommendations to farmers who have high-velocity systems, that they enlarge the lateral openings to reduce the constriction in the opening, or install vanes to prevent the air from piling up against one side of the opening. In some of the older systems with a tapered main duct, the air made an acute-angle turn. These are now being modified to enlarge the radius of the turn, or to reduce the angle.

For the designer, it is necessary that he understand the mechanics of air flow—in other words, be able to visualize what happens to air in movement—and calculate the cross sections and bends to avoid unequal distribution. With these mechanics in mind, he will quickly arrive at formulas that will take care of each situation as it arises. There will be no need to refer to a standard plan devised by some distant engineer. For an air flow of 24,000 cfm, the designer will at once divide by the velocity he wishes to use and arrive at the initial cross section. Having determined where the main duct is to be placed, he will proportion the air to be delivered from any section, according to the volume of hay to be served. When the sections have been laid out, the entrance velocity desired in the laterals will determine the cross section of the total lateral entrances and this is then divided by the number of laterals. The design of the main duct is then complete.

The design of the lateral system is more complicated than that of the main duct. The laterals should compensate as far as possible for unequal resistance in the hay. The ideal lateral is one which in itself creates little resistance to the flow of air as long as the air flow is distributed evenly. If, however, the resistance in the hay varies, then the lateral outlets should be of such a cross section that they automatically impose a resistance if the outlet velocity increases. This in itself will not balance the distribution of the air. It can only prevent the mass escape of air through some low-resistance channel.

Numerous types of laterals have been designed. With few exceptions, they have been superimposed on the hay mow floor. And it seems probable that the laterals of the future will also be superimposed. The possible exceptions will be in new barns, or in cases where new floors are being constructed. In the latter case, it is possible to devise the lateral system between the joists as has been done in several cases that have come to my attention, but there seems to be little merit in considering subfloor distribution at the present time.

MOST LATERALS ARE OF THE INVERTED TROUGH OR THE SLATTED FLOOR TYPE

Most laterals are of the inverted trough or the slatted floor type, or a combination of the two. Slatted floors seem essential for baled hay, and they are often a necessity for loose hay in deep, narrow mows. Because chopped hay is composed of small pieces, the inverted box is generally used to avoid clogging, although slatted floors have been successfully used.

Perhaps of more importance at present than a standard design for laterals is the necessity for continued research on lateral outlet areas and velocities required for chopped hay, baled hay, and loose hay of various kinds. Considerable progress is being made in various experiments, but the work needs to be continued until there is little question as to the method of emitting air with the least possibility of unequal distribution.

Perhaps of equal importance is the design of laterals that can be detailed simply, so that the average farmer or rural carpenter understands from the blueprint exactly how they are to be constructed. This is true of the entire distribution system. It must be drawn in a simple manner that supplies all the necessary dimensions in a plain pattern. Members of the A.S.A.E. Farm Structures Division know from long experience that the rural builder is characterized by his habit of accepting a blueprint which he conveniently disregards because he either fails to understand the importance of following the plans, or because he cannot understand them. A mass of detail is not required. Simple pictures and dimensions with statements as to the nature of the material and construction are far better than complex detailed plans. It is very desirable that features such as barn posts and braces be shown so that the plan will appear in relation to existing construction.

It would be very convenient if I could offer the final solution to design, but as long as barns vary in mow dimensions and the hay varies in its requirements for volume, each system must be designed on a basis of experience and formula.

The Needs of a Farm Structures Program

By Deane G. Carter
FELLOW A.S.A.E.

FARMERS need new and better buildings and they want help in planning them; industry has the plant capacity and the organization to supply the services and materials of construction; and public agencies are alert to the demand for research, education, and planning aids. It is the agricultural engineer's responsibility to project a postwar farm structures program that contributes to the solution of farm building problems inherent in this situation.

Agricultural engineering has accepted professional responsibility for the farm structures as a phase of its program. Structures development has lagged behind other engineering activities in agriculture, and more emphasis must be given to this field. Both in industry and public service, agricultural engineering is now regarded as the logical medium for farm structures design and interpretation and the application of principles to the building needs.

The professional is undermanned to take advantage of the opportunity to perform an effective service. The current directory of the American Society of Agricultural Engineers lists only 22 members from the colleges of agriculture whose major technical interest is farm structures. Only 19 are listed from federal government and agencies, and some of these are not directly concerned with agricultural problems. About 65 commercial and industrial members are in this group, but relatively few of them are engaged in the professional and technical phases.

The average farm barn in the north central region of the United States was built without the benefit of technical knowledge of requirements, efficiency, conservation, and economy because the principal professional and technical developments in farm structures have occurred mostly in the last 40 years; and the average age of the barns is about 40 years. Within this 40-year period, fundamental changes have affected the character and use of farm buildings, and important research has contributed to a better understanding of requirements and solutions. The conversion of structures to meet new conditions and needs has been long delayed.

The most significant fact of structures development is the change in the approach to the solution of problems. The first approach was *subjective;* that is, the structure itself was the aim, and the design or recommendation was based on physical principles, experience, or opinion. Gradually but unmistakably, the attack has become more nearly *objective,* wherein the structure is but an instrument or a device that contributes to a goal of function and economy.

Functional utility and a concept of basic requirements are major problems at this time; however, the solution of these phases alone is not sufficient. Economic limitations cannot be ignored. Basic principles must be made effective through plans and specifications. The value of the individual structure depends upon its relationship to the farmstead and whole farm program. The complex nature of farm building design and application requires research, planning aids, and personnel trained in the science of farm structures.

The purpose of group discussion is to examine the specific problems of present interest and explore the ways and means of performing a more useful service. As the basis for discussion, the following points are pertinent:

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1945.

DEANE G. CARTER is professor of farm structures, University of Illinois.

1 *A More Adequate Concept of the Need for and Functions of Farm Structures.* Under certain conditions, limitations of farm size, capacity, management, or finance prevent the adoption of recommended practices.

Farm structures are frequently regarded as real property improvements, or as an expense to be endured, or as facilities that have to be supported from farm income.

Can the amount to be invested in structures be determined by the amount remaining after other expenses of production are met?

Is there an arbitrary limit to the sum that can be spent for buildings for a given enterprise? Is the farm overbuilt if that is exceeded? Or are there other considerations involved? Might it not be necessary to develop two sets of recommendations, one for commercial production and another for subsistence farmers?

What can farm structures contribute to efficiency of production? Is such efficiency largely dependent upon management?

2 *Offsetting Existing Deficiencies.* There is competition between structural improvements and other goods and services needed by the farmer.

General economic conditions have prevented normal improvements.

There is a conflicting interest between durability, permanence, and high initial investment, and flexibility of use, changes in agriculture, tenant occupancy, and limited resources.

What service can be rendered to assist farmers in remodeling, repairing, and adapting existing buildings?

What would be the effect of a disparity between the price of farm products and the cost of building?

3 *Farm Dwelling Improvement.* Both the dwelling structure and the farmhouse utilities have important engineering implications.

Approximately one-half the farm building investment in Illinois is for the dwelling; the ratio varies by regions and states, from about 40 to 60 per cent on the average.

The dwelling is essential to the operation of the family farm. In addition to providing housing for the operator and his family, the dwelling contributes to farm production and is important in setting the family living standards.

The interrelation between the dwelling and the farm unit affects the plan of the farmhouse. Since professional services are not generally available for farmhouse planning, should the farmhouse have attention from the agricultural engineer equivalent to that given other structures?

4 *Farmstead Organization for Efficiency, Health, and Enjoyment.* Farm structures design involves the relationship of one building to another; separation if necessary for fire safety or sanitary control; esthetic values of form, size, color, style, and planting; distribution of utilities service; efficiency in the use of time and labor; and economy in specific operations.

5 *Definition of Functional Requirements.* The basis for precise definition must come from research that is closely coordinated with investigations in agricultural production and management in established research institutions.

Basically there can be but one set of fundamental requirements for production or storage. Modifications must be made, however, to conform to differences in climate, market outlets, purposes of production, size of enterprise,

capacity of management, and production resources, such as feed and labor. Frequently management is a more important factor than the structure.

Currently the development of statements defining functional requirements is done by the U. S. Department of Agriculture, individual states, regional groups, and private organizations. It is imperative that such work be closely coordinated.

6 *Farm Structures Research.* Structures research has been extremely limited. Principal limitations are personnel, funds and public support, and a lack of understanding of the significance of the various problems.

Future research programs must include aspects of economy, management, environment, efficiency of operation, sanitary control, effect on production, flexibility of use, standardization of designs, production processes, and structure and material considerations. Such programs involve research interests in production, biological science, and economics as well as engineering.

The proposed federal legislation for endowment of farm structures research is worthy of mature consideration. It is based on the principle of public research for the benefit of all farmers and the entire industry as opposed to direct contributions of public funds for part or all of the building facilities for individuals. The amount proposed annually is less than one-half of one per cent of the conservatively estimated expenditures for farm buildings in the immediate postwar period.

7 *Extension Education.* There is need to define the scope of agricultural extension service aid in farm structures. Bulletins, circulars, plans, and the services of state specialists is the accepted practice in the landgrant colleges. Industry supplies similar aids through trade promotion, association activity, and dealer relations.

Available aids leave much to be desired in quality of service and value to the individual farmer.

Assistance to extension agents, materials dealers, builders, and other local and regional leaders offer the advantage of efficiency with limited staffs and an opportunity to avoid errors in advisory services.

Is there justification for public support for more educational aids? Is there a common ground on which industry and public service can work together to meet the need?

8 *Training of Personnel.* The demand for workers in the farm structures field far exceeds the supply. There is no comprehensive program at present for professional training in agricultural engineering for farm buildings and rural housing. Engineers, architects, and home economists are trained in some fundamentals but not in the intensive specialization that is needed.

What courses and curricula are necessary to provide the needed training? Should they be on a graduate or undergraduate level? Is it best to train students in a separate curriculum or to supplement other curriculums with some specialization? Can an individual specialize in all phases, or must there be several individuals each with special training to concentrate on a given problem?

In the near future, it may be advisable to offer limited courses, from one week to a year in length, as refresher courses or as special subject matter courses for orienting available personnel to the field of farm structures.

9 *Planning Services.* Blueprint plans were first distributed about 40 years ago. With the increasing demand, the service has become a part of the extension service in most colleges of agriculture. In some cases, 1000 or more plans are distributed each month.

It is doubtful if commercial, federal, or regional plan services can substitute in full for the state service if purely local needs are met, and if there is a continuing development of plans to interpret results of research.

Some public plan service must be maintained to cover the areas of planning not directly related to industrial interest, such as farmstead plans, homemade or very low-cost devices and plans that delineate arrangements or procedures.

Many economies could be effected in plan services by regional plan production and coordination among the states and between public services and industry.

The objective of public service plans is primarily to show basic outlines and requirements and interpret research. Plans from industry supplement general plans with specific details of material, use, and construction. Much of the difficulty with plan services lies in the amount of detail included in public service plans and the lack of basic recommendations to guide industry in the preparation of its plans.

There are five planning services in the farm structures field: commercial, state, regional-government, industry, and industrial groups—the latter just now in prócess of organization.

The solution to the problem of planning services is a most important undertaking for the profession. The primary consideration should be to render the most effective service to the farmer.

10 *Coordinating and Integrating Industry and Public Service Activity.* The membership of the American Society of Agricultural Engineers is made up of men from professions, industry, and public service. The Society's objective must be professional advancement and development. There is no Society obligation to promote farm structures as such. The Society does, however, provide a common bond of interest and thereby facilitates consideration of problems in a particular field.

Much can be done within the Society to coordinate the varied interests of the membership. In farm structures, it should be possible to visualize the functions of each interest for the common good of the members and of agriculture.

Industry could advance the program of structures by cooperating in extension education, supporting research at the experiment stations, promoting public aid to research, assisting in training leaders, and providing technical specifications and details for use of materials.

Public service could supply research findings to industry, cooperate in using educational facilities already established, train workers for industrial positions, supply basic information for plan preparation, and publish adequate literature on subjects of general interest.

The Engineer for Agriculture

A CONSTRUCTION engineer can build a good barn roof truss, but it takes an agricultural engineer to design a dairy barn for efficient production of high-grade milk.

An electrical engineer may develop or improve an electric fence, light, motor, or other equipment from the standpoint of its electrical characteristics, but fitting it into a program for low-cost production on farms is an agricultural engineer's job.

A mechanical or automotive engineer may improve internal-combustion-engine design to give higher thermal efficiency, but the men who improve tractors from the standpoint of power application and control in farm operations are, in fact, agricultural engineers.

A civil engineer may be the master of water from the standpoint of flow characteristics and control structures, but the control of water for maximum benefit and minimum cost to farm production programs is agricultural engineering.

Bluegrass Terrace Outlet Channel Design

By Dwight D. Smith
MEMBER A.S.A.E.

COMPLETION of tests on bluegrass terrace outlet channels during the past two years at the Missouri Soil Conservation Experiment Farm near McCredie, Missouri, has made available sufficient data for development of outlet design curves and tables. These curves cover a wide range of flow depths for bluegrass at two growth stages: one in late May when the grass is headed out and offers its greatest resistance to flow, and the other in late October and November when the pliable green leaves easily shingle the channel floor to give a very smooth surface over which the water may flow.

A previous paper published in 1943[1] by the author gave a description of the experimental facilities, the tests that were planned, and the techniques followed in securing the data. In addition to these tests, a series of low-velocity tests were made for the purpose of securing data applicable to certain phases of airport design. Fig. 1 shows the apparatus for measuring rate of flow for the low-velocity tests.

Limiting Velocities for Bluegrass. In outlet design the first problem is to select the maximum average velocity of flow. This involves consideration of numerous factors. Good quality bluegrass sod has withstood very high flow velocities without damage under certain channel conditions. The top growth had to be thick and long enough to shingle the channel surface completely. For grass 2 to 4 in in height a greater thickness of stand was required to prevent scour than for the grass 6 to 12 in tall. The scour was not always in proportion to the velocity. It occurred as soon as the water forced an opening in the shingled surface, even though the velocity was relatively low. Any loose soil and organic matter was removed first. After this the scour was generally small until the extremely high velocities of flow were reached.

Channel irregularities, such as humps or depressions, quickened parting of the shingled grass and allowed scour to begin. Crawfish or gopher holes had similar effects. Sudden decrease in channel bed slope resulted in increased scour at, and just beyond, the point of decrease, although an increase in bed slope did not have this detrimental effect on the grass. Weather hazards, such as extremely high temperature and long periods of either drought or excessive rainfall, may appreciably reduce the density of the bluegrass. This is especially true on the claypan soils in the southern part of the corn belt. Farther north and on soils of higher fertility than the claypans this weather factor is of much less importance.

The tests do not indicate a definite limiting velocity below 15 fps (feet per second) for high-quality bluegrass. Uncertainty of maintenance, the possibility of poor channel alignment, damage from rodents, cattle and farm implements, and the hazards of weather make necessary the recommendation of much lower velocities than the maximum attained in the tests. Also, damage caused by low velocity runoff over a prolonged period may set the stage for severe damage from a storm of high intensity coming before the sod re-establishes itself.

The accuracy with which rate of runoff for a given frequency may be determined must be considered as a factor in determining the maximum design velocity. Various methods yield results that vary widely. It would seem logical to use a different maximum velocity for a 10-year frequency than for a 50-year frequency runoff.

The inclined point quadrat, as used by ecologists and agronomists to measure grass cover, was used to secure a measure of the vegetation in the test channels. The number of strikes per needle is referred to as the grass density. It is a measure of both thickness of stand and length of leaves and stems. Fig. 2 shows this apparatus in use.

Grass with a density below 2 strikes per needle has provided little protection against scour. This is illustrated in Fig. 3. Grass with a density above 2 strikes per needle was affected very little by relatively high velocities of flow, as shown in Fig. 4. Table 1 shows the grass density that should

Table 1. Limiting Velocities for Bluegrass of Different Densities as Determined by the Inclined Point Quadrat

Maximum design velocity, feet per second	Minimum grass density, strikes per quadrat needle	Soils 6 in or more in depth and in high state of fertility
1	1.0	
2	1.5	
3	2.0	
4	3.0	Putnam (claypan soil)
5	4.0	Shelby
6	5.5	Marshall
8	8.0	

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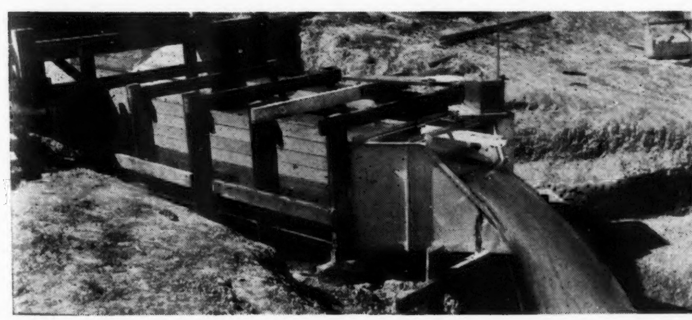
DWIGHT D. SMITH is project supervisor, Soil Conservation Service (Research), U. S. Department of Agriculture.

[1]Bluegrass Terrace Outlet Channels, Agricultural Engineering, vol. 24, no. 10, October, 1943.



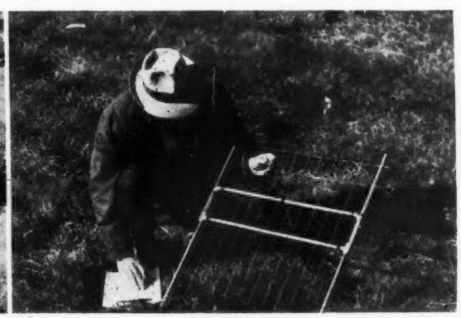


Fig. 1 *(Left)* The apparatus for determining rate of flow for the low velocity tests. The flow is 4.1 cfs • Fig. 2 *(Right)* The inclined point quadrat used for the determination of grass density

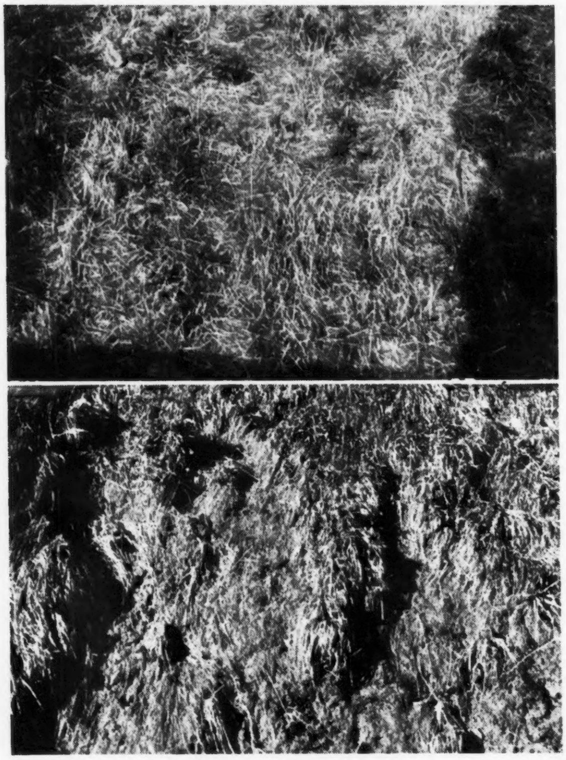


Fig. 3 A poor fall growth of bluegrass with a density of about 1 strike per quadrat needle before testing *(top)*, after testing *(bottom)*. Velocities of 4 to 9 fps removed most of the sod clumps

give adequate protection against scour for velocities ranging from 1 to 8 fps.

A maximum design velocity of 4 fps appears satisfactory for the claypan soils of Missouri that have 6 in or more of top soil, and which have received sufficient soil treatment to bring them to a good state of fertility. Very good bluegrass sod outlet channels which could withstand considerably higher velocities generally can be developed on such soils. Experience has shown, however, that the quality of the sod may deteriorate seriously during periods of extremely high temperature and drought, or on flat slopes during prolonged periods of excess rainfall.

The effect of temperature on the quality of the sod is shown by the variation in grass counts on each side of the test channels. Nine of the channels point southeast. The northeast banks with their southwest exposure to the hot afternoon sun had an average grass density of 3.7 strikes per needle in comparison to 5.0 on the opposite banks with the northeast exposure. This relationship was consistent on all 9 of the channel sections. The most dense grass was on the V-shaped channels. It averaged 6 strikes per needle. The side slopes were 6 horizontal to 1 vertical.

On the trapezoidal channels grass counts on the bottom averaged 2 strikes per needle in comparison to nearly 4 on the sides. The count on the 4 per cent bed slope channel bottom was 33 per cent greater than for the 1 per cent bed slope. These differences on the trapezoidal channels appear to be the result of poor drainage during prolonged periods of excess rainfall.

On the better soils of north Missouri, where the weather hazards are less and the soil fertility and internal drainage more favorable for the growth of bluegrass, design velocites of 5 or 6 fps can be recommended with safety. If the quality of the sod can be maintained at a level where the minimum density does not fall below 7 to 8 strikes per needle, a design velocity of 8 fps may be used. Runoff rates should be for a 25-year frequency.

Relationship of Hydraulic Factors. The formula used most frequently in open channel design has been Manning's

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \qquad [1]$$

in which V is mean velocity in feet per second; R, the hydraulic radius or channel area divided by the wetted perimeter, and S, the slope of the water surface if flow is uniform or of the energy gradient if the flow is non-uniform in feet per foot of channel length. For drainage and irrigation work where R was almost always greater than 1, n was a constant for a given channel lining. In terrace outlet channel work R is almost always less than 1. S is more often 5 ft drop per hundred feet of length than per mile as in drainage work.

Calculation of n by use of the Manning formula and the test data showed that n was not a constant but varied from a maximum for low flow when the grass stood erect, to a minimum when the grass was completely shingled and the hydraulic radius approached a value of 1. n was affected by velocity, slope, hydraulic radius, and grass density and stage of growth. Fig. 5 shows headed bluegrass erect, and in two stages of submergence.

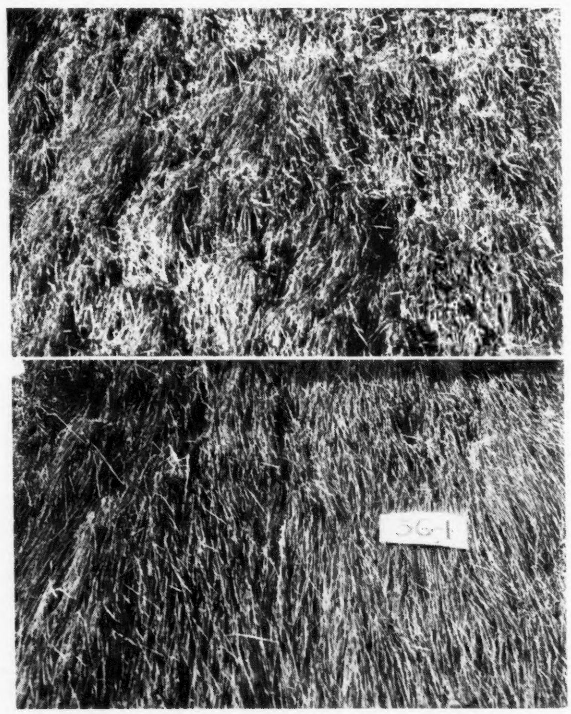


Fig. 4 *Top:* This fall growth of bluegrass with a density of 2.3 strikes per needle was not damaged by the maximum test velocity of 7 fps. Grass of a similar density on other channels withstood a velocity of nearly 15 fps, without significant damage. *Bottom:* This fall growth of bluegrass on a V-shaped channel was not damaged by the maximum test velocity of nearly 9 fps. Grass on the right half with a southwest exposure had a density of 4.5 strikes per needle, while that on the left, with a northeast exposure, had a density of nearly 7 strikes per needle

Study of data[1,2,] showed that exponential equations could be derived for n and V, which would represent sections of the data, one for the grass erect, one during shingling, and another after shingling was complete. The exponent of the slope factor in the equations for n was approximately 1/6, and in the equations for V, 2/3. The exponent of the hydraulic radius in the velocity equations varied from 0.8 to 1.2. As no one equation represented the data throughout the complete range, a graphical solution as developed by Palmer[3] appeared more satisfactory.

The low velocity test data on headed bluegrass showed that bending of the grass began when the product of the velocity times the hydraulic radius equalled 0.1, regardless of the magnitude of the slope factor. For the fall growth stage the product was about 0.06.

[2]Some New Hydraulic Data. H. L. Cook, Proc. Highway Res. Board, 18th annual meeting, 1938, Part I.

[3]Design Curves for Bermuda Grass. V. J. Palmer, Stillwater Hydrologic Lab., SCS.

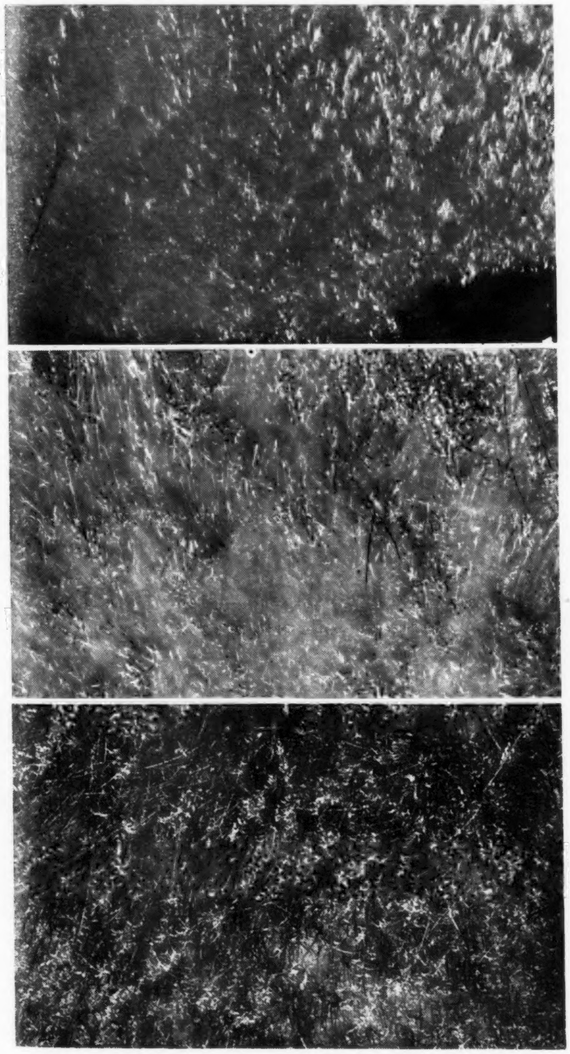


Fig. 5 Late May growth of bluegrass during low-velocity tests. Density of the grass is 6 strikes per needle. *Top:* The velocity was 0.32 fps and *VR* value 0.074. *Center:* The velocity was 0.69 fps and the *VR* value 0.23. *Bottom:* The velocity was 1.28 fps and the *VR* value 0.45

All bluegrass data were plotted with n as a function of the product (VR). Two distinct curves were secured for the two growth stages of bluegrass. They are shown in Fig. 6. By this method the slope factor as a variable is eliminated.

Bluegrass in the fall does not retard the flow of water during shingling as much as in the late spring when the stiff seed stems are present. There is little difference in retardance for the two growth stages before shingling begins. Also, as shingling becomes more complete and the grass is pressed closer to the soil, retardance values for the two growth stages come together.

The cross-section area of flow for each test included the area occupied by the grass. This area was found to be a maximum when all of the bluegrass was incorporated with the flow. It occurred at a VR value just beyond 0.23 for both growth stages of the grass, and amounted to 3 per cent of the measured cross-section area. As the VR values increased, the percentage decreased. At VR equal to 5.0, the percentage was 1.5. As the VR values decreased from 0.23, less of the grass was incorporated in the flow. Also the grass density was practically uniform below the height for this point. For these reasons the percentage of the cross-section area occupied by the grass decreased a small amount. Measurement of the thickness of the grass lining was made after the grass had been combed and compressed by the high velocity flows. It averaged approximately 1/8 in in thickness. The density by the inclined point quadrat was about 6 strikes per needle.

Design Curves and Tables. The n-VR curve of Fig. 6 for headed bluegrass, when combined with the Manning formula, made possible the preparation of the design curves shown in Fig. 7. The equation in terms of VR were written:

$$V = \frac{1.077\,(VR)^{0.4}\,S^{0.3}}{n^{0.6}} \qquad [2]$$

and

$$R = \frac{0.788 n^{0.6}\,(VR)^{0.6}}{S^{0.3}} \qquad [3]$$

From the curves of Fig. 7 the value of R may be secured corresponding to the desired velocity of flow and slope of the outlet. The value of n may be read also from the curve of Fig. 7 for the desired velocity and slope of the outlet. If desired, it may be plotted against the corresponding values of R taken from the curves. It is not used, however, in the final solution of the outlet size as the value of R is secured direct from the curves.

The discharge from the area draining into the outlet may be computed by several methods, or taken from tables previously prepared. With the discharge of Q known, and the selected V, the channel cross-section area may be determined by the equation:

$$Q = AV \qquad [4]$$

For the trapezoidal channel with 4 on 1 side slopes the area is:

$$A = WD + 4D^2 \qquad [5]$$

in which W is the bottom width and D the center depth. W and D must be selected to satisfy the value of A from equation 4 and in addition satisfy the value of R read from the curves of Fig. 7.

$$R = \frac{A}{WP} = \frac{WD + 4D^2}{W + 8.25\,D} \qquad [6]$$

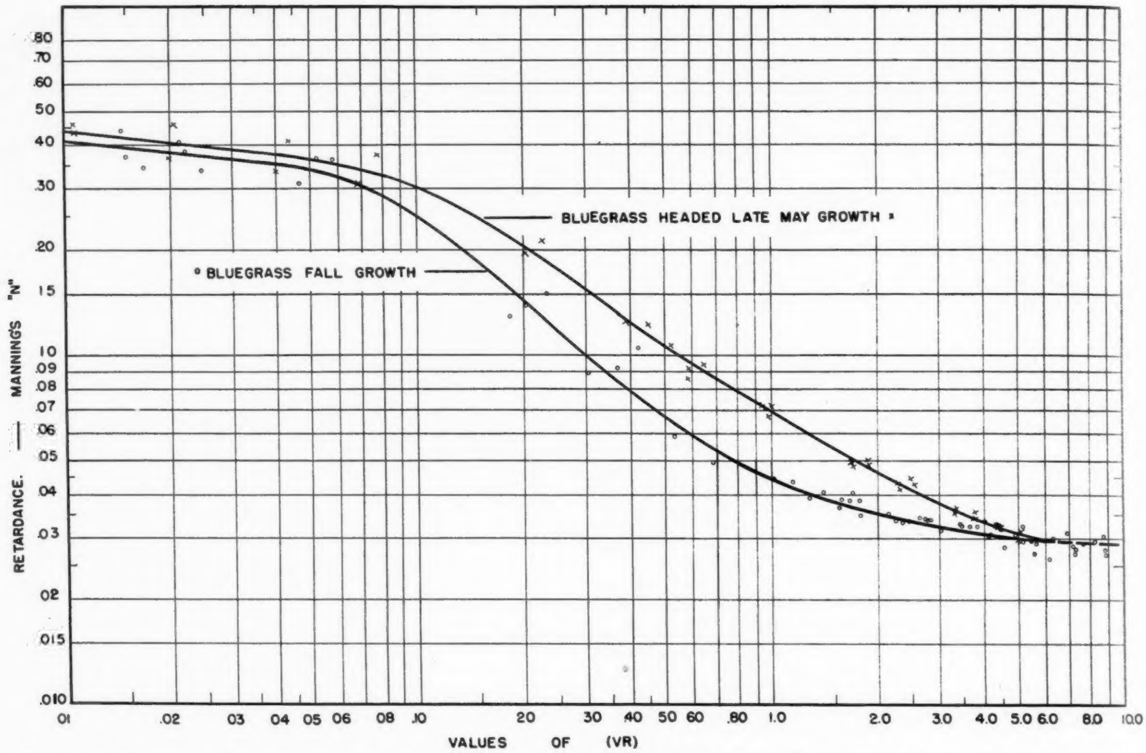


Fig. 6 *N – VR* curves for Kentucky bluegrass. Tests in trapezoidal channels with bed slopes from 1 to 20 per cent, during May 1943-1944 and October, November, 1942-1944. Missouri Soil Conservation Experiment Farm, McCredie, Missouri

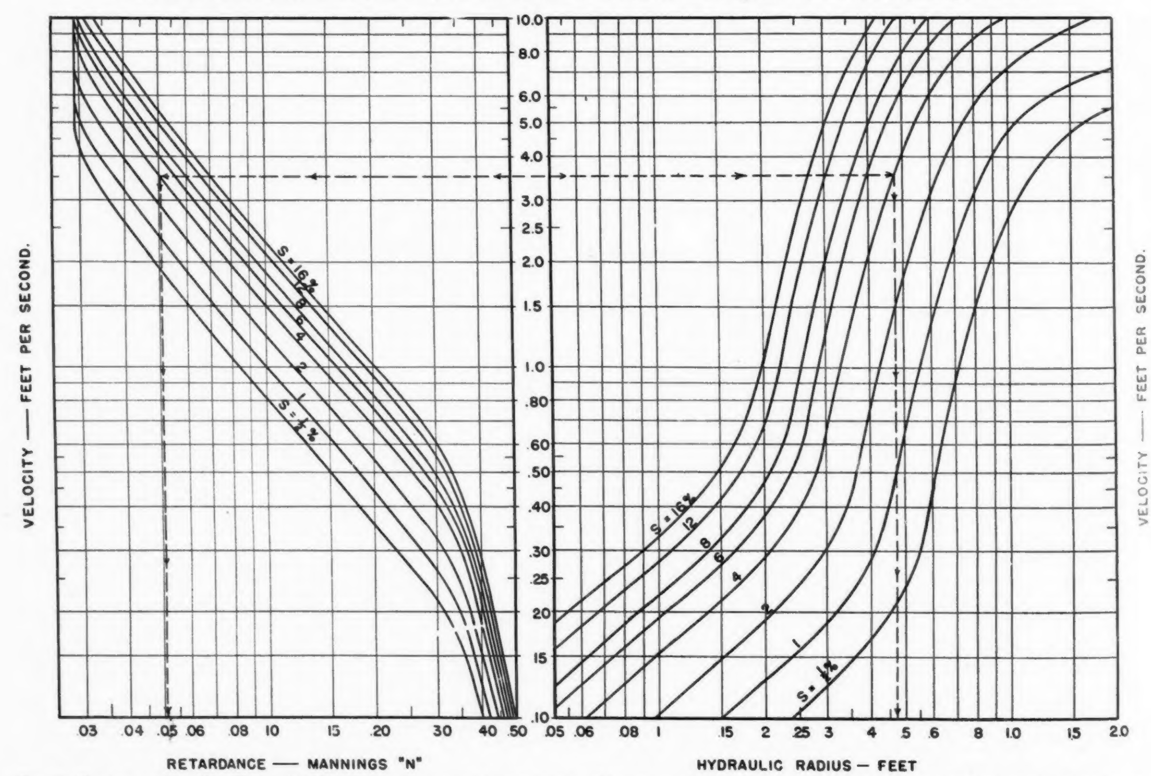


Fig. 7 Design curves for Kentucky bluegrass terrace outlet channels. Bluegrass at its maximum growth stage (headed out). Curves developed from data secured at the Missouri Soil Conservation Experiment Farm, McCredie, Missouri

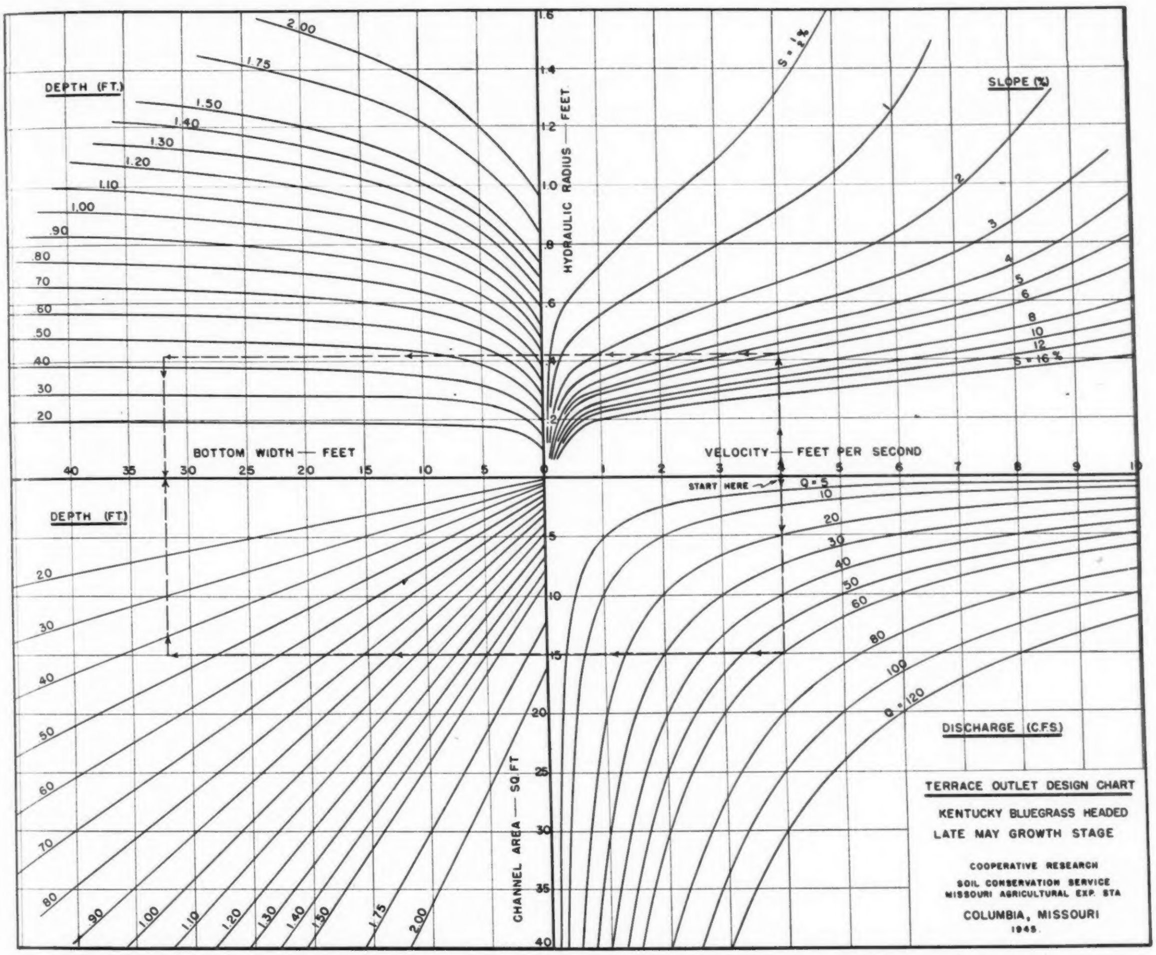


Fig. 8 Terrace outlet design chart for Kentucky bluegrass at its maximum growth stage (headed out). Curves developed from data secured at the Missouri Soil Conservation Experiment Farm, McCredie, Missouri, during the period 1943-44

This is a laborious task as a direct solution is not possible. To simplify the procedure the curves of Fig. 8 were prepared. In the use of the chart the first step is to select the desired maximum average velocity of flow. From this point on the velocity scale proceed both upward to the required slope curve and downward to the required Q curve. From these two points proceed horizontally to the left until the same depth curves are reached so that the R-W point is directly above the A-W point. Then read the bottom width on the left center scale. Guide lines on the figure illustrate the procedure. The selected velocity is 4 fps and the required Q is 60 cfs. The depth determined by the chart is 0.44 ft, and the width read on the left center scale is 32 ft.

Use of a chart like Fig. 8 will require study and practice. Simpler charts, perhaps of the nomograph type, will be developed. Until they are, Fig. 8 may be used to prepare outlet size tables like Table 2. This table was prepared for the claypan prairie soils of Missouri, using 4 fps as the average maximum velocity of flow. A rate of runoff curve for areas of different size was prepared by the method given in the Region 3 engineering handbook of the U. S. Soil Conservation Service.

For the smaller acreages and particularly the flatter slopes the expected quantity of flow was not sufficient to support a 4-fps average velocity. For these conditions, which are to the left of the heavy lines in the table, a maximum width of 6 ft was selected and the depth determined for the maximum average velocity that the quantity of flow would support. In practice it is often desirable to use a constant-width outlet. In most cases the maximum width selected will be at the point of maximum slope. This width may then be continued up the slope where the drainage area generally decreases sufficiently to balance the decrease in capacity due to the decrease in slope.

Redtop, Timothy and Other Grasses of the Corn Belt. Mixtures of timothy and redtop when tested in late May yielded *n-VR* curves practically identical to those for headed bluegrass, as shown in Fig. 6. Thus the design curves of Figs. 7 and 8 may be used for these grasses at this stage of growth. Retardance during shingling will probably be a little greater at their maximum growth stages of late June and early July when they are headed than for headed bluegrass. Tests to check this point are planned for the future.

Alta fescue and brome grass have been seeded in channels for future testing. Alta fescue appears particularly promising as a channel lining.

Redtop and timothy seeded together and tested in May when one, two and three years of age, offered about the same retardance and protection from scour, regardless of

TABLE 2. BLUEGRASS TERRACE OUTLET SIZE TABLE FOR CLAYPAN PRAIRIE AREA OF MISSOURI

Percent slope of outlet	Acres Q (c.f.s.) Area (s.f.)*	2 7.5	4 13.5 3.4	6 19. 4.8	8 24. 6.0	10 30. 7.5	12 35. 8.8	14 40. 10.0	16 44. 11.0	18 49. 12.3	20 54. 13.5	24 63. 15.8	28 72. 18.0	32 80. 20.0	36 89. 22.3	40 97. 24.3	45 108. 27.0	50 118. 29.5
1	Width - Ft. Depth - Ft. Velocity *	6 .77 1.1	6 .88 1.6	6 .96 2.0	6 1.03 2.3	6 1.10 2.7	6 1.14 2.9	6 1.18 3.1	6 1.23 3.3	6 1.27 3.5	6 1.30 3.7	6 1.37	10 1.24	12 1.18	16 1.13	18 1.10	21 1.08	23 1.06
2	Width - Ft. Depth - Ft. Velocity	6 .63 1.4	6 .70 2.2	6 .79 2.7	6 .84 3.1	6 .89 3.6	6 .93 3.9	8 .90	9 .87	12 .83	14 .81	17 .78	21 .76	24 .75	26 .74	30 .74	34 .73	38 .72
3	Width - Ft. Depth - Ft. Velocity	6 .54 1.7	6 .63 2.6	6 .68 3.2	6 .73 3.7	7 .73	10 .69	12 .67	14 .65	17 .64	19 .63	23 .61	27 .61	31 .60	35 .60	38 .60	44 .59	
4	Width - Ft. Depth - Ft. Velocity	6 .50 1.9	6 .57 2.9	6 .62 3.6	7 .64	10 .61	13 .59	15 .57	17 .57	20 .55	22 .55	27 .54	32 .53	36 .53	40 .53	44 .53		
5	Width - Ft. Depth - Ft. Velocity	6 .47 2.1	6 .54 3.1	6 .60	9 .55	12 .52	15 .51	18 .50	20 .49	23 .49	26 .48	31 .48	36 .48	40 .48	45 .47			
6	Width - Ft. Depth - Ft. Velocity	6 .44 2.3	6 .51 3.3	7 .52	10 .49	14 .47	17 .47	20 .46	23 .45	25 .45	28 .45	35 .44	39 .44	44 .44				
8	Width - Ft. Depth - Ft. Velocity	6 .39 2.6	6 .45 3.8	9 .44	13 .42	17 .41	20 .40	23 .40	26 .40	30 .39	33 .39	39 .39	45 .39					
10	Width - Ft. Depth - Ft. Velocity	6 .37 2.8	7 .41	11 .39	14 .38	19 .37	23 .36	26 .36	29 .36	33 .36	37 .36	44 .35						
12	Width - Ft. Depth - Ft. Velocity	6 .35 3.0	8 .37	12 .36	16 .35	21 .34	25 .34	29 .33	32 .33	36 .33	40 .33							
16	Width - Ft. Depth - Ft. Velocity	6 .32 3.3	9 .32	14 .31	19 .30	24 .30	28 .30	32 .30	36 .30	42 .29								

*Velocities to the right of heavy line are 4 feet per second. Areas are for this velocity.

age. Only a limited amount of scour occurred with test velocity as high as 8 fps. Bluegrass when one year of age did not provide adequate protection for velocities of 3 fps and greater. After the second year, bluegrass had developed a sod equal in retardance and protection from scour to that of bluegrass three or more years of age.

SUMMARY

Bluegrass terrace outlet channels have been tested hydraulically at two growth stages, one in late May when the grass is headed out and offers its greatest resistance to flow, and the other in the late fall when only the pliable leaves shingle the channel to give a very smooth flow surface. Depth of flow varied from a fraction of an inch to about 1 ft, to give design data for the grass erect, through shingling, and when shingling was complete.

Maximum average velocity of flow is limited by the density of grass that the soil can produce and maintain, the possibility of damage from rodents, cattle, and farm machinery, and the uncertainty of maintenance and weather.

Recommendations are made for a 4-fps average velocity for the claypan prairie soils of Missouri, and for velocities up to 8 fps for soil and climate areas in which high quality sod with density of 7 to 8 strikes per needle can be assured over a long period of time.

A design chart is presented by which outlet size may be determined quickly when the maximum velocity of flow has been selected and the slope of the outlet and the expected maximum quantity of flow are known.

Training Agricultural Engineers

(Continued from page 112)

institutions should have enough of the foundation subjects in mathematics, physics, engineering, agriculture and professional agricultural engineering to handle agricultural engineering problems in any part of the globe. In fairness to the students we must provide training that will give them confidence and pride to tackle the jobs ahead.

In addition to training in theory, I am old-fashioned enough to believe in some practical training for students. All of us may not be in agreement on this subject, either, but there appears to be sentiment for retaining some of the practical work in our curriculums. Recently a graduate of two midwestern universities, who taught seven years, did research for a manufacturer of electrical equipment two years and is now on terminal leave from military service, expressed his thoughts on the subject about as follows: "My only suggestion in connection with training agricultural engineers is that more practical work be injected into the program. In my opinion the training should include complete exhibits of commercial items, including materials, machines, instruments and tools with which the agricultural engineer may have to work. While in school he should be required to learn the approximate cost of these items, how and where they are used and where they are obtained. He should learn to gather scientific as well as commercial information, and start a good personal file of such information. He should be inspired in this way to see the necessity of the purely academic part of his work. When he has seen applications, then he is ready to learn the scientific background for design." Undoubtedly we should consider the merits of such constructive thoughts of our recent graduates. It is the student's welfare we have in mind—his future and the service he is to render to society.

Another very important phase of training agricultural engineers is the graduate program. Approximately half the institutions offering work toward the bachelor's degree also offer instruction leading to advanced degrees. Unless other departments offer graduate work, these colleges will be hard taxed to meet the demands of graduate students. Agricultural engineering is a broad field and a higher degree of specialization is possible in a graduate program.

(Continued on page 133)

Farm Power

By J. Brownlee Davidson
FELLOW (CHARTER) A.S.A.E.

THE increase in the use of power on the American farm, and the resulting progress in agriculture, has been the principal influence in placing America in the lead among nations in the production of food and fiber. As progress has been made, labor has become less and less a matter of brawn and more and more a matter of intellect. Labor is now largely confined to the guidance and direction of the energy supplied from other sources. It is recognized that energy cannot be applied directly to agricultural production but must be used to drive or actuate machines. For this reason the process of utilizing power is generally referred to as mechanization. Furthermore, it should be understood that power, machines and labor must be properly related in a productive program if it is to be economically successful. The management of these elements of production is basically the art and science of engineering. Power may be introduced into the productive enterprises of any industry when the cost and character of labor can be reduced or changed.

As a motor—the producer of power or energy—man is hopelessly outclassed. Experiments conducted many years ago (see "The Animal as a Machine and Prime Mover" by R. H. Thurston) revealed that a mature man of average size in good physical condition could develop, at a treadmill or capstan, 1/10 hp for 8 hr a day. If the wage of the laborer is $1 per hour, the cost of power from man labor is $10 per hp-hr. This cost may be compared with that of a farm tractor where the power at the drawbar may be 5c or less per horsepower hour, or one-half of one per cent as much as the cost for man-developed power. The cost of power from stationary internal-combustion or electric motors may be even much less than that from a tractor.

When the United States achieved independence in 1776, the farmers of that period in America, as well as those in Europe, cultivated and cared for their crops with the same crude practices and with the same simple implements that the Egyptians and Israelites had used more than 2000 years before. In the growing of grain the soil was plowed with a wooden plow, the seed was broadcast by hand, harvested with a scythe and threshed by beating with a flail on the barn floor.

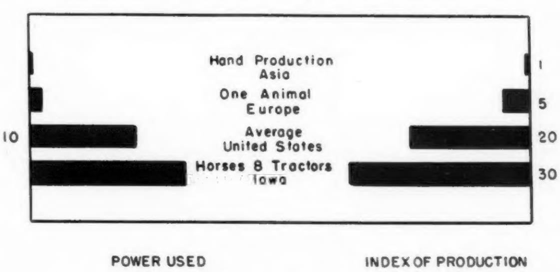
It is estimated that on July 1, 1945, the American farmer had a power plant of more than 100 million primary horsepower or about 10 hp in motor capacity for each person gainfully occupied in agriculture. The farmer's power plant is made up of many kinds of motors, namely, windmills, steam engines, stationary engines, motor trucks, electric motors, and the two most important motors—(1) tractors and (2) animals (horses and mules). It is estimated that on July 1, 1945, there were 2,150,000 tractors and over 10 million mature work animals on the farms of the United States. The introduction of so much power into agricultural production has had such a profound and far-reaching influence upon the whole agricultural industry that it is difficult to comprehend. It is true that much progress had been made in other phases of agricultural production, such as better soil management, the development of higher yielding varieties of crops (improvement of the quality of products), the control of insect pests and diseases, and the production of more efficient livestock. There is no attempt in this paper to minimize in any way these achievements. It is a matter of record that yields were often very good on virgin soils during the early periods of American agriculture, and much has been gained by shifting crops to the more favorable soils and climate conditions.

The introduction of power into agriculture has resulted in a tremendous advance in the productivity of labor. This is indicated by the great reduction in the number of workers required. As late as 1840, according to the United States Census data, 77.5 per cent of the persons gainfully occupied were in agriculture. By 1900 the percentage had declined to 35.7 per cent and the 1940 census revealed that only 18.5 per cent were so employed. During World War II the percentage has been materially reduced, and it was estimated that for 1945, only one-sixth of the total number of available workers were needed for agricultural production. During the period from 1840 to 1940, while the number of persons gainfully occupied in agriculture increased three times, the production of the eight principal cereals increased nine times. Thus it is clear that, on the basis of cereal production, over 57 per cent of the man power of the country has been released from agriculture for other productive pursuits.

That the productive capacity of the farm worker is closely related to the power used may be illustrated by statistics from the various states and from other countries. The accompanying graph indicates this relationship based upon the best information available.

Another way of illustrating the effect of the use of power upon the productiveness of agricultural labor is to consider the equivalent number of slaves, required in slavery times, to equal the power used. Since each American worker has ten primary horsepower in motors to aid him and each horsepower is the energy equivalent of ten slaves, each worker has the equivalent of 100 slaves to aid him. This is about the number wealthy slave holders had in the time of the Revolution. Thus, we have in the use of power a revelation of the secret of America's outstanding agricultural production. Power has enabled fewer and fewer workers to furnish the necessary food, fiber and shelter required for all.

It is clear that there has not been a general appreciation or understanding of just what this increased production per worker has meant. Some have been anxious lest it result in unemployment. It is true that there are problems of adjustment, but the desirability of increasing the production of the worker in agriculture is becoming well established. It is now quite generally accepted as axiomatic that *in a self-contain-*



This graph illustrates the relation between power used and volume of agricultural production per worker

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1945.

J. BROWNLEE DAVIDSON is professor and head of agricultural engineering, Iowa State College.

ed community the smaller the proportion of workers required to produce food, the greater will be the number available to produce the commodities and services which will advance the material well-being of all. The employment of released workers is one of the nation's great problems in any adjustment, such as that resulting from the war, but, on the other hand, the availability of manpower affords a great opportunity for progress and for providing a higher standard of living for all.

For many years the animal was the principal source of power for the farm. In early American agriculture oxen furnished a notable share of the power used on the farms. Their number reached a peak in 1860 at 2¼ million, declining thereafter to an insignificant number in 1940. Horses, on account of their faster gait, have been the most popular work animals. The number of mature work horses reached a peak in 1910 at 17½ million and has declined to 7½ million in 1945.

Although the internal-combustion engine was to be found on farms in 1900, the first tractors powered with this type of prime mover were in use to the number of only 10 thousand in 1910. Since then the gas tractor, so-called, has increased steadily until the estimated number in use in 1945 was 2,150,000.

The change from animal motor to the internal-combustion engine has not been an easy matter. The animal delivers its power as a pull, as it travels forward at a relatively low and nearly constant speed. It has the advantage of a tremendous overload capacity—1000 per cent, for a few seconds. On the other hand, the engine furnishes power in the form of rotary motion at high speed. At the beginning of the change from animal to mechanical power, a multitude of farm machines for farm work were all adapted to the animal and its linear motion. To accommodate the many field machines the early designer undertook to make in the tractor a motor with the characteristics of the horse, or, in other words, a horse with wheels instead of legs. Such a tractor permitted the use of the established field machines or implements but did not capitalize the inherent characteristics of the internal-combustion engine—rotary motion and high speed. Some progress, however, has been made. The power take-off has been added to drive the parts of field machines requiring rotary motion, such as the harvester-thresher combine and corn picker. By mounting the tractor on pneumatic tires the field speeds have been more than doubled.

The introduction of the tractor was delayed in those areas where row or intertilled crops were grown, because it was not fully sensed that the tractor, if it were to meet with favor, had to displace the horse. The duplication of power plants by the farmer was not economically sound. In many instances the designers of tractors did not understand the agricultural requirements of the tractor, and advancement was limited to mechanical improvements. The importance of providing a "general-purpose" tractor with sufficient versatility to furnish all of the power for growing corn and cotton is understood when the importance of these crops in the United States is considered.

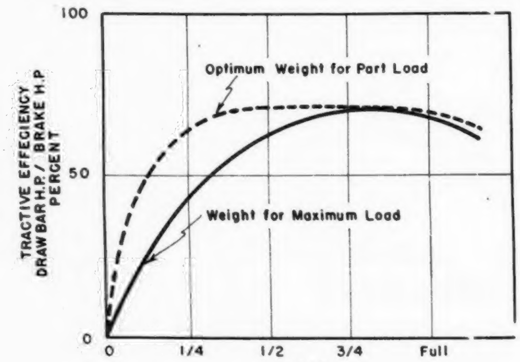
Another requirement which was not fully sensed was the necessity for the combined control of the tractor and implement by the one operator. The ox and the horse could be trained to follow furrows and obey commands and to a degree the animal became self-controlled and the driver was given the opportunity to supervise the implement. The inability to do this with a tractor was considered a serious drawback, until it was found that the control of the tractor and implement could be combined by mounting the implement on the tractor. The control of the combination of tractor and machine became even easier than the control of the machine when drawn with animals.

Having a power plant in the tractor capable of furnishing power when the tractor is not in motion has led to the development of many convenient labor-saving attachments in the way of lifts and adjusting mechanisms. The nature of these devices is indicated by some of the terms used in describing them, such as "finger tip" or "feather touch" control.

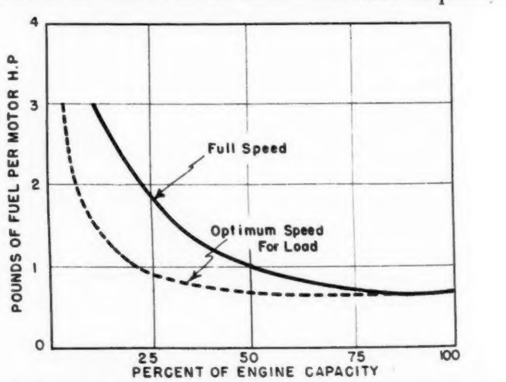
An improvement in the durable qualities of the tractor motor has contributed greatly to the increasing popularity of tractor power.

Formerly, motors needed to be overhauled after about a thousand hours of service. Now, due to improved materials, better design and manufacture, and particularly due to the improvement in facilities of keeping dust and grit away from the working parts, some motors have made phenomenal records of long use between overhauling. Improved ignition and fuel systems have likewise made contributions of inestimable value to the reliability of the internal-combustion motor.

A concensus of opinion has not been reached as to the type of fuel most suitable for tractor use. Tractor designers are perhaps divided into four schools. First, there are those who believe that for economy the tractor motor should burn the heavier and cheaper motor fuels usually designated as distillates. The policy in certain states of exempting such fuel from tax while taxing the more volatile fuels has contributed to continued use. Although cheaper, such fuel has the disadvantage of making the motor difficult to start when cold, and it is asserted that when this fuel is used the motor must be overhauled more frequently.



This graph shows the effect of reducing weight on tractive efficiency at part load



This graph shows how the optimum speed for an internal-combustion engine reduces fuel consumption for part load per unit of power developed

The second school of designers provides a motor to burn the regular or most common fuel in use in motor cars. These designers feel that with the modern cracking processes used in the refining industry there should be little difference in cost, and its convenience in starting, and the greater economy in storing a fuel in general use, more than compensates for the difference in cost.

A third school of designers would use a fuel of relative high octane or suitable for use in a high-compression engine without preignition. More power is secured for a motor of a given size, and starting characteristics are very good. At the present time such fuel sells at an extra or premium cost.

The fourth group of designers are those who believe in the service and future of the Diesel type of internal-combustion engine. This type of motor burns a special heavy fuel now sold at a reasonable cost and is the most economical in fuel consumption of all motors at the present time.

Time only will determine just what type or types of internal-combustion engines will furnish the most desirable power for farm tractors.

It may not be out of place here to take a forward look and suggest some of the changes that may come to the farm tractor. All engineers agree that advantage is not taken of the light weight of the internal-combustion engine in the conversion of its power to drawbar power. Now it is customary to add weight to the tractor in the form of cast iron disks or water in tires to give traction or adhesion to the ground. The hauling about of this extra dead weight to increase traction, when additional traction is not needed, is an unjustified loss of energy. Self-propelled field machines avoid this serious criticism. Furthermore, in some instances the tractor and its related equipment is so designed that much of the weight of the machines is carried on the tractor chassis. The thing that is not provided with the conventional tractor is a ready and conventional means of changing weight as needed. Perhaps the most readily available source of weight is the soil. The farmer looks forward to the *variable-weight tractor* which will be loaded with extra weight only to the amount needed.

The rate at which certain field operations can be carried out is proportional to the amount of power available. Thus, only about one-half as much time is required to plow a given area with a four-plow gang as with a two-plow gang. In such a case the larger unit conserves labor, but the amount of power that can be utilized for some other operations is limited. Thus, for plowing, a tractor of 35 to 40 hp output might well be used, but for other operations such as planting or cultivating row crops, only 5 to 10 hp can be used efficiently. At the present time farm engines must be operated at the most desirable speed for the heavy power tasks, and are thus operated very inefficiently at light loads. A variable-speed motor operating, say, at a speed of 1600 rpm when 40 hp is required, and at only 400 rpm when 10 hp is needed, would not only make for economy of fuel consumption but would extend the life of the engine. The automobile motor is an example of a variable-speed motor. Of course, suitable gear combinations would be needed in the transmission to furnish the correct field speed and the problem of a variable-speed governor is a difficult one.

Although the use of power has had a profound influence on American agriculture and the internal-combustion engine is making great advances, it is rather clear that the changes in the application of power to farm operations in the years just ahead may be the most significant of those of all time.

Training Agricultural Engineers

(Continued from page 130)

A critical need at the present time is for agricultural engineering textbooks of a more technical nature. Many of the available books were written several years ago, and it is obvious that scientific developments have taken place since then that should be incorporated in new texts. It is hoped that there will be new editions in the near future and that more of our members will direct their talents toward writing textbooks for use by students majoring in agricultural engineering.

We should be responsible not only for training our own native students but also for training foreign students. We have already graduated a few foreign students, but from present indications increasing numbers of students from many countries of the world will be coming to our institutions to specialize in agricultural engineering. It is my opinion that we should facilitate this trend, and if necessary outline courses to meet specific needs of foreign students. In this manner we may contribute toward better relationships with other countries of the world and establish valuable contacts for the exchange of goods.

The place for agricultural engineering in the colleges and universities has long been a subject for discussion in meetings of the Society. It is predominately in the schools of agriculture, even though in some institutions it is strictly in the school of engineering. In other institutions the curriculum is administered by both schools. It is awkward from the professional point of view to condone this situation, but, after all, it is the curriculum and what is put into the various courses of study that determines how well the students will be trained. Eventually administrative procedures may be the same in all institutions, but while this change is taking place we should keep on training men to the best of our abilities.

Today's challenge to the agricultural engineer is for him to apply engineering knowledge to the solution of agricultural problems. It is the same today as it was in 1907, but there are more tools to work with and more recognized fields of service. To meet the challenge we must train capable men in adequate numbers so that the problems will be solved efficiently and economically.

"Salute to the Schoolmaster"

TO THE EDITOR:

I GET a delightful reaction from the editorial, "Salute to the Schoolmaster", in AGRICULTURAL ENGINEERING for February. For many years, it has seemed to me that agricultural engineering departments and the A.S.A.E. have given too little attention to the field of resident instruction.

Probably every college man, whether he be in teaching, research or extension work, or in all of these fields, has known hundreds of cases when class work was neglected for the sake of reaserch work, the excuse given being that the class could wait but that the research job must be done on that particular day or lose its significance. While the latter part of the statement is true in many instances, it is not a good reason for neglecting the training of oncoming men. This is an outgrowth of the system of working men in two fields, sometimes necessary but not always advisable.

The suggestion that it is the administration's responsibility requires clarification. I believe the responsibility for an equitable distribution of effort between research, teaching and extension is up to the department head even more than to the institutional administration. The department head should have a primary interest in one of the three fields of work, only administering the other two; or if the department is large enough, devote his time to administrative activities only.

If it is within the province of the Secretary of A.S.A.E. and if he has the power to influence the membership, I believe it would be well worth while to encourage greater activity in the College Division and keep the activities of the Division devoted wholly to the instructional phases which I believe was the original intent.

E. R. GROSS

NEWS SECTION

Minnesota Section Meets March 22

THE Minnesota Section of the American Society of Agricultural Engineers will hold its first annual meeting and dinner in the Coffman Memorial Union, University of Minnesota, Minneapolis, on Friday, March 22 at 6:00 p.m. It will be an open meeting and anyone interested in agricultural engineering is invited to attend. Reservations for the dinner should be made not later than March 18, and should be mailed to the Section secretary, P. W. Manson, Agricultural Engineering Building, University Farm, St. Paul.

Penn Section Has New Secretary

ROBERT J. McCALL, extension agricultural engineer, Pennsylvania State College, has been appointed by Paul J. Newton, chairman of the Pennsylvania State Section of the American Society of Agricultural Engineers, to the office of secretary of the Section to fill out the unexpired term of E. W. Schroeder who recently resigned his position at Pennsylvania State College to join the agricultural engineering staff of the Tennessee Valley Authority where he will be in charge of farm machinery research.

Southeast Section Elects Henderson

AT THE business session of its meeting held at Birmingham, Alabama, February 13 and 14, the Southeast Section of the American Society of Agricultural Engineers elected G. E. Henderson, chief, agricultural engineering development division, Tennessee Valley Authority, as its new chairman for the ensuing year, succeeding Wm. E. Meek, special agricultural sales engineer, International Harvester Co.

Other officers of the Section elected include the following: First vice-chairman, James L. Shepard, research agricultural engineer, Georgia Coastal Plain Experimental Station; second vice-chairman, J. H. Lillard, associate agricultural engineer, Virginia Agricultural Extension Service, and secretary-treasurer, Harry Dearing, agricultural engineer, Tennessee Coal, Iron and Railroad Company.

A total of 108 persons, most of them A.S.A.E. members, were registered, a record-breaking attendance for a Southeast Section meeting; and all but four of these attended the Section dinner during the evening of the first day. The dinner, incidentally, was made the occasion for an inspiring address by J. Dewey Long, president of the Society, whose subject was "The Professional Agricultural Engineer."

Several excellent papers were presented during the meeting, which will find there way into the columns of AGRICULTURAL ENGINEERING in the coming months.

At the close of the meeting, Section officers were giving serious consideration to an invitation sponsored by high government officials of the Republic of Cuba to hold the 1947 meeting of the Section in Havana. The invitation was personally presented to the meeting by an A.S.A.E. member, Sr. Jose Garcia Inerarity of Cuba.

New officers elected at the recent A.S.A.E. Southeast Section meeting: Left to right, G. E. Henderson, chairman; J. H. Lillard, 1st vice-chairman; J. L. Shepherd, 2nd vice-chairman; H. W. Dearing, Jr., secretary-treasurer. At the extreme right is Sr. Jose Garcia Inerarity of Cuba, one of the speakers at the meeting

A.S.A.E. Meetings Calendar

March 22 — MINNESOTA SECTION, Coffman Memorial Union, University of Minnesota, Minneapolis.

April 19 and 20 — SOUTHWEST SECTION, Blackstone Hotel, Fort Worth, Texas.

June 24 to 27—ANNUAL MEETING, New Jefferson Hotel, St. Louis, Mo.

December 16 to 18 — FALL MEETING, Stevens Hotel, Chicago, Ill.

Southwest Section Meets April 19 and 20

THE Southwest Section of the American Society of Agricultural Engineers will meet at the Blackstone Hotel in Fort Worth, Texas, on April 19 and 20. Hotel reservations should be made direct with the hotel, and should specify that they are for the A.S.A.E. Southwest Section meeting, also the kind of accommodation desired and number of nights rooms are needed. The program for the meeting will be announced shortly, and copies may be had by writing the Section secretary, Kyle Engler, University of Arkansas, Fayetteville, or to A.S.A.E. hearquarters at St. Joseph, Mich.

Ray Crow a City Manager

MEMBERS of A.S.A.E., who know him, will be surprised to learn that Ray Crow, who recently resigned his position with the Tennessee Coal, Iron and Railroad Company to go into "retirement", was recently elected city manager of Mountain Brook, a suburb of Birmingham, Alabama. The election grew out of some consulting engineering work which Mr. Crow did recently for the city. It is assumed that the latchstring of the city manager's office will be out for any of Mr. Crow's old friends in A.S.A.E. whenever they happen to be in the vicinity of Mountain Brook.

S.C.S.A. Organized

THE letters in the title stand for the "Soil Conservation Society of America," which has been organized to "promote and advance all phases of the science of conservation of soil and water resources; to provide a medium for exchange of facts, experience, and thought, and to present, advance and protect the standards of the science of soil and water conservation."

Dr. Hugh H. Bennett, chief, Soil Conservation Service, USDA, is listed as founder of the new Society, with Ralph H. Musser, Milwaukee, Wis., as president, A. E. McClymonds, Lincoln, Nebr., as vice-president, and J. H. Christ, Portland, Ore., as secretary-treasurer.

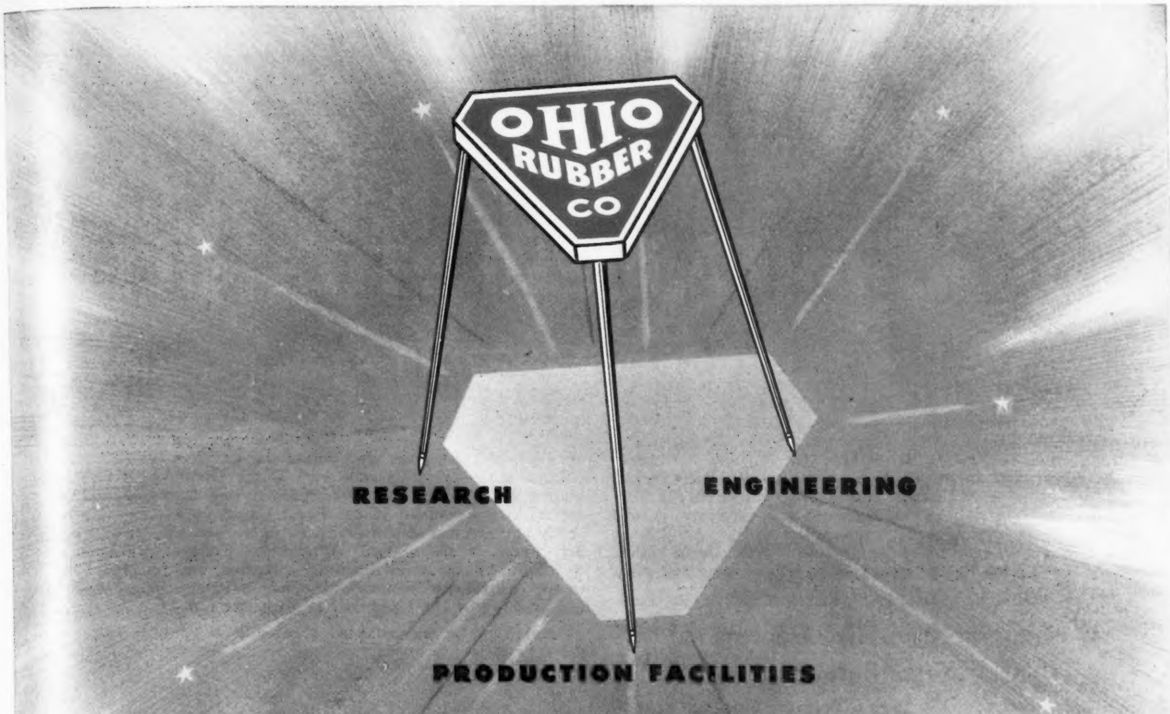
The Society since it was organized last year has enrolled 1500 members and has granted charters to ten chapters with headquarters in Washington, D. C., Portland, Ore., Huron, S. D., Lincoln, Nebr., Salina, Kans., Bozeman, Mont., Milwaukee. Wis., Upper Darby, Pa., Spartanburg, S. C., and Fort Worth, Tex.

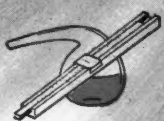
Information regarding membership in the organization may be obtained from the secretary-treasurer, J. H. Christ, P. O. Box 671, Portland 7, Ore.

"Agricultural Engineering Record"

LAST fall the National Institute of Agricultural Engineering, Askham Bryan, York, England, began publication of a quarterly periodical with the above title, the purpose of which is "to place on record, for the benefit of manufacturers and farmers, results of the work of the N.I.A.E., the progress of other development and research workers, and observations of practical farming." In an introductory statement in the first issue, S. J. Wright, director of N.I.A.E., stated that it is proposed to publish in the "Record" summaries of as many as possible of the reports of tests conducted by the Institute on various agricultural machines. Space will be devoted also to the findings of the "Farm Mechanization Enquiry" being conducted by the Institute.

The autumn 1945 issue of the "Record" contains articles on segmented sugar-beet seed, grain losses with the combine harvester, experiments on sugar-beet harvesting, grain-bin ventilation, a grain flowmeter, a coulter for plowing-in straw, and an offset potato digger. The winter 1945-6 issue con- *(Continued on page 136)*





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NEWS SECTION

(Continued from page 134)

tains articles on farm machinery trends in the U.S.A., pneumatic grain conveying, potato planters, farm carting, a swinging windrow, implement development, pneumatic tires on farm tractors, and a carbon disulphide applicator.

The "Record" is obtainable by annual subscription at a price of 4s. 4d. including postage, and subscription orders may be sent to The Secretary, N.I.A.E at Askham Bryan.

Refrigeration Abstracts

TO ASSIST in filling the large number of requests for technical information about refrigeration received daily, the American Society of Refrigerating Engineers has just issued the first issue of a quarterly publication known as "Refrigeration Abstracts". It presents in concise easily read form, brief abstracts of technical articles on refrigeration that have appeared in about 300 U.S. and British papers during the previous year. The list will be extended to include other periodicals, books, and reports, and to include literature from other countries. It is edited by J. Mack Tucker, associate professor of mechanical engineering, University of Tennessee, assisted by a staff of 58 engineers and scientists. It will be available on subscription to non-members of the A.S.R.E. at $7.00 per year or $1.50 for a single copy. Subscription orders should be sent A.S.R.E. headquarters, 40 West 40th St., New York City.

Washington State Give Impetus to Structures Research

LAST November, with the State College of Washington, state building materials groups, farm cooperatives, and electric power utilities cooperating, what is to be known as the "Washington State Farm Structures Research Foundation" was organized to undertake a farm buildings research program covering the function, design, materials, equipment, location, arrangement, and utilization, the primary purpose of which is to bring farm building standards to levels of higher efficiency. The Foundation will start its first year of activity with a $15,000 budget. The research program will be supervised and carried out by the agricultural engineering department of the State College of Washington at Pullman.

New American Standard in Building Field

THE American Standards Association announces that it has approved an "American Standard" on the basis of which building materials and equipment of coordinated sizes and dimensions will be made available to construction operations, and building plans and details can be correlated with such dimensions. The new standard is designated A62.1-1945 "American Standard Basis for the Coordination of Dimensions of Building Materials and Equipment", which is the basic standard. Another American Standard also approved is designated A62.2-1945 "American Staudard Basis for the Coordination of Masonry," which is supplementary to the other standard.

The project which has resulted in these standards was organized by the A.S.A. in 1939 with the American Institute of Architects and the Producers Council, Inc., as joint sponsors. A guide providing information for the architect, engineer and builder as to building layout and details, in conformity with these standards, is now in preparation.

These two American Standards are now being printed and will be available on application to American Standards Association, 70 East 45th St., New York 17, N. Y.

The discharged veteran of World War II wears this emblem. Remember his service and honor him.

Personals of A.S.A.E. Members

H. A. Arnold, agricultural engineer, Tennessee Agricultural Experiment Station, is author of Bulletin No. 194 of that station, entitled "Seed Scarifiers".

Nils Berglund, who has been teaching farm machinery at the agricultural college at Uppsala, Sweden, for several years, is now also director of the Swedish Institute of Agricultural Engineering, founded last year. The Institute is also located at Uppsala and has as its main objective to carry on research work on the application of agricultural machines and implements. He will give special attention to farm mechanization which has made more progress in Sweden than in any other country of Europe.

Lawrence Collins, who attained the rank of colonel in the Army during the war, has returned to civilian life and has established the Collins Agricultural Service at Denver. He will offer a consulting service on farm management and other agricultural problems.

C. G. E. Downing, who before the war was engaged in agricultural engineering research work at the Dominion Experimental Station at Swift Current, Sask., Canada, and who during the war served as a lieutenant in the Royal Canadian Air Force, was recently appointed professor and head of the agricultural engineering department of the Ontario Agricultural College at Guelph, and will be in charge of all teaching, extension, and research work in th the department. Mr. Downing is a 1940 agricultural engineering graduate of the University of Saskatchewan.

Irby S. Exley has accepted a position as research assistant in the department of agricultural engineering, University of Georgia, and will work on a project on processing farm products.

G. Price Grieve, after serving forty-nine months in the Army, most of it in the South Pacific, where he attained the rank of major, is a civilian again and has joined the staff of Frank J. Zink Associates, agricultural engineers, as a specialist on farm marketing problems relating to the farm structures and machinery fields. Prior to going into the Army, Mr. Grieve was an agricultural engineer with the Portland Cement Association.

Robert E. Hartsock, following a six month's period of consulting engineering work for the Aerco Corporation of Hollydale, Calif., was recently made chief engineer of the organization.

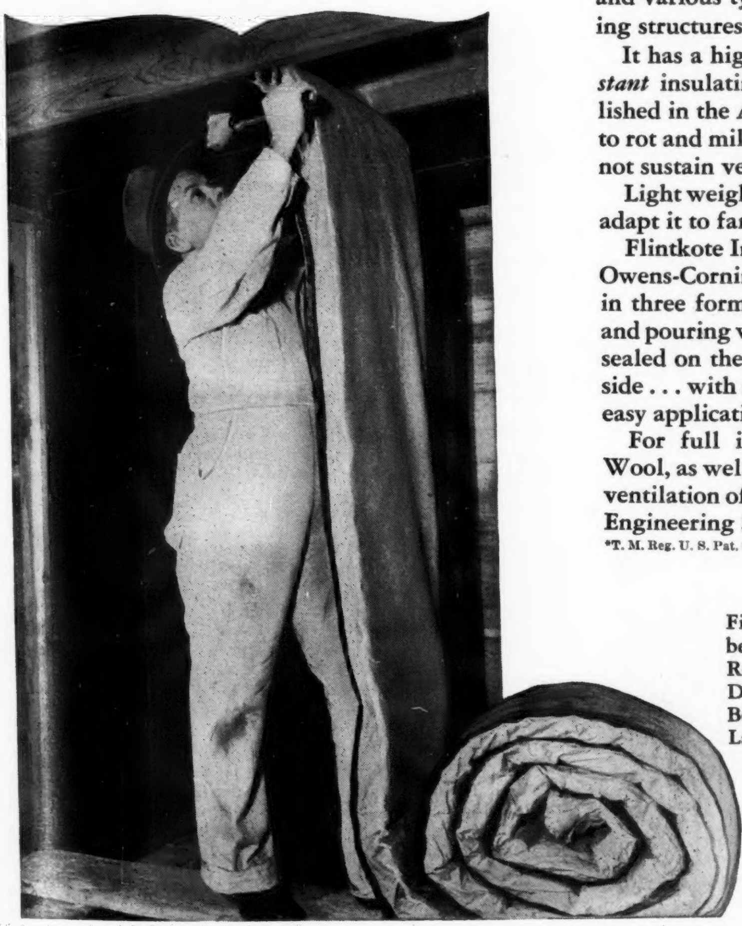
(Continued on page 138)

George W. Kable, past-president of the American Society of Agricultural Engineers and editor of "Electricity on the Farm" magazine, is shown here (right) receiving the National Safety Council Award of Honor for distinguished service to farm safety from John H. Wetzel, head, safety and health section, U. S. Soil Conservation Service, during the meeting of the A.S.A.E. North Atlantic Section at New York City last November. The announcement of the award appeared on page 430 of AGRICULTURAL ENGINEERING for October, 1945

Flintkote pouring wool in place between ceiling beams.

•

Insulating a ceiling with Flintkote Roll Blanket. The same method is used for wall surfaces.



Flintkote Insulating Wool (Fiberglas*) has many advantages of particular interest to farmers, especially for the walls and ceilings of animal shelters and various types of storage facilities and processing structures.

It has a high, and when properly installed, *constant* insulating factor ("K"=.27 BTU), as established in the A.S.H.V. & E. Guide. It is impervious to rot and mildew; and since it is spun glass, it will not sustain vermin, absorb moisture or odor.

Light weight, and its ability to retard fire, further adapt it to farm building design.

Flintkote Insulating Wool, manufactured by the Owens-Corning Fiberglas Corporation, is marketed in three forms . . . blankets in roll and batt forms and pouring wool. The batts and blankets are vapor sealed on the inside and vapor porous on the outside . . . with a specially-designed nailing flange for easy application.

For full information on Flintkote Insulating Wool, as well as technical details on insulation and ventilation of farm buildings, write Flintkote Farm Engineering Service.

*T. M. Reg. U. S. Pat. Off.

FLINTKOTE FARM PRODUCTS

Fire-resistant Asphalt Shingles – Fire-proof Asbestos Sidings–Insulated Sidings–Easily-applied Roll Roofings – Cold Process Built-up Roofs – Dampproofing Materials–Decorative Insulation Board–Insulation Sheathing Board–Insulation Lath for Plaster Base.

The Extra Years of Service Cost No More!

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If It's MOBILE

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— and that means Wheels properly suited to the work to be done.

We invite you, as a manufacturer of mobile equipment, whatever its nature, to submit your Wheel Specifications to us. Perhaps we can recommend STANDARD WHEELS and HUBS adaptable to YOUR duty.

Send Your Wheel Problems to Us

FRENCH & HECHT, INC.
SUBSIDIARY OF KELSEY-HAYES WHEEL CO.
DAVENPORT, IOWA

Wheel Builders Since 1888

Personals of A.S.A.E. Members

(Continued from page 136)

G. L. Hazen recently started on agricultural engineering research work with James Manufacturing Co., Fort Atkinson, Wis.

Fred Meyer, Jr., who served with the Army engineers during the war, is again a civilian and is employed by the U. S. Soil Conservation Service at Scott City, Kansas, in the capacity of soil conservationist and farm planner with the Scott County soil conservation district.

Maurice W. Nixon has resigned his position with the engineering department of J. I. Case Co., at Burlington, Iowa, to join the engineering department of Hertzler and Zook Co., Belleville, Pa.

Glen E. Page, who has been serving as an engineer with the Goodyear Aircraft Corp., has recently joined the agricultural engineering staff at Purdue University where he will be employed as assistant in the agricultural experiment station on grain drying work.

Bruce E. Pettit, who served with the Corps of Engineers of the Army during the war, attaining the rank of major, is now a civilian again and is employed as an engineer on design of portable irrigation systems for the Atlas Supply Company of Muskogee, Okla.

David Poor has accepted a position as agricultural engineer for the Stran-Steel Division of Great Lakes Steel Codporation, and will work out of its Detroit office.

Albert E. Powell, until recently a research senior fellow in agricultural engineering at Iowa State College, is now office engineer for the Structural Clay Products Institute with headquarters at Ames, Iowa.

Joe B. Richardson, who served in the AMG organization of the Army during the war with the rank of first lieutenant, has returned to civilian life, and taken up his duties again as assistant agricultural engineer at Clemson Agricultural College.

June Roberts, who served in the U. S. Naval Reserve during the war, obtaining the rank of lieutenant, has received his discharge and has returned to his former position of investigator, Committee on the Relation of Electricity to Agriculture, for the state of Washington, which position makes him a member of the agricultural engineering staff of the State College of Washington at Pullman.

L. E. Sample, who served as a captain of Anti-Aircraft Artillery during the war and who has been more recently connected with an irrigation company in Florida, recently accepted a position as assistant to the chief engineer of the United Irrigation Company in the Rio Grande River Valley and is located at Mission, Texas.

J. P. Schaenzer, who has been acting head, special problems section, technical standards division, Rural Electrification Administration, USDA, has been made head of the new electro-agriculture section of REA recently announced by Administrator Claude R. Wickard. The new section has been set up in REA's Technical Standards Division to organize, promote, and coordinate programs in the development of new electro-agricultural equipment and the improvement of existing devices of benefit to the farmer. It will strive for the development of new electrical equipment designed to meet farm needs and will cooperate with colleges and other groups carrying on research programs.

E. W. Schroeder, who has been a member of the agricultural engineering staff of Pennsylvania State College for several years, recently resigned to accept a position in the agricultural engineering development division of the Tennessee Valley Authority where he will have charge of farm machinery research.

E. S. Shepardson, extension instructor in agricultural engineering, New York State College of Agriculture, has prepared Bulletin 673, entitled "Protection for Electric Motors," which was issued last year. The information in the bulletin is particularly applicable in the use of electric motors in farm applications.

Robert F. Skelton, who for several years has been connected with the B. F. Goodrich Company and engaged in rubber track development work, recently resigned to accept a position as engineer with the Belle City Manufacturing Co. at Racine, Wisconsin.

J. W. Sorenson, Jr., a major in the 142nd Infantry during the war, has returned to civilian status and has accepted appointment as associate agricultural engineer in the division of agricultural engineering of the Texas Agricultural Experiment Station.

James L. Strahan, agricultural engineer, The Flintkote Company, is author of an article, entitled "Heat and Ventilation in the Design of Dairy Stables", published in "Heating and Ventilating" for January, 1946. Copies are available in the form of a reprint on request to Mr. Strahan.

Lonnie S. Thompson, who served as a major in the field artillery of the Army during the war, is a civilian again and is associated with the U. S. Soil Conservation Service. He is a soil conservationist and work unit leader for the Service in Warren County, North Carolina. *(Continued on page 140)*

Atlas was first with these:

Need help on blasting problems?

CALL ON **ATLAS** FIRST!

No two blasting requirements are exactly alike—even on the same job. That's why the use of the right explosive, in the right amount, in the right way calls for cooperation between men who know explosives, and you, who know your operation.

More and more men are calling on Atlas *first*. That's because Atlas has led in new developments — because Atlas is interested in the development of new methods and products—because Atlas is *willing* to be of help on blasting problems.

Do you need help on some blasting problem? We will be glad to match our "know-how" on explosives with your experience and knowledge of your job. Working together is the best way to get the best results for the least expenditure of money.

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NEW CONTINENTAL

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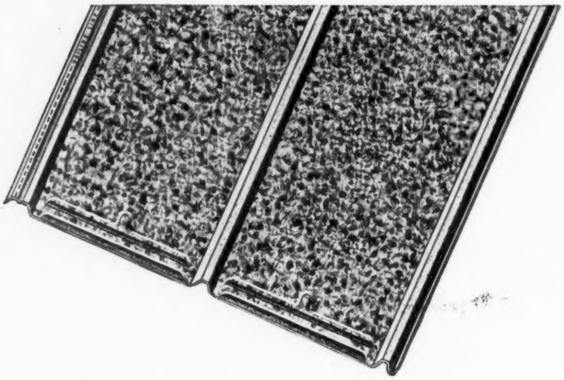
STEEL ROOFING AND SIDING



Here's a new steel building sheet with advanced features. Continental's new TYL-LYKE steel roofing and siding has style and strength. Its all-weather lap has a nailing line to insure proper nailing, and a new drip bead to protect against seepage. Made of special analysis steel and galvanized by the Superior Process. Get TYL-LYKE steel roofing and siding from your local Continental dealer. See him for all your needs including fence and barbed wire.

NEW

GRASSLAND FARMING

MANUAL

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Just off the press . . . a timely, practical, new 40-page manual about the promising new system of farm management called Grassland Farming. Write for this new manual today.

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GENERAL OFFICES • KOKOMO, INDIANA

PRODUCERS OF – 15 Types of Farm Fence, Posts, Gates, Barb Wire — 14 Styles of Steel Roofing and Siding, and Fittings — Nails, Staples, Lawn Fence, Wire Products

Personals of A.S.A.E. Members

(Continued from page 138)

Allison H. Stephenson, who served in the anti-aircraft artillery of the Army during the war, attaining the rank of captain, has been discharged and is now part owner of a garage business at Bedford, Virginia.

Necrology

HILTON ORREN THOMPSON, according to word received from Mrs. Thompson only recently, was killed in a practice dive bombing mission over the English Channel on July 19, 1945. Lieutenant Thompson has the distinction of having shot down the last Nazi plane in the European war theatre.

Lieutenant Thompson was a native of Louisiana and attended Louisiana State University, from which he obtained a degree in engineering with a major in agricultural engineering in June 1942. On graduation he was appointed an engineering aide in the maps and surveys division of the Tennessee Valley Authority, but it was not long thereafter, however, that he entered the armed forces in the service of his country.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send inforamtion relative to applicants for consideration of the Council prior to election.

E. Keith Arthur, p-1 engineer, U. S. Bureau of Reclamation. (Mail) Vernal, Utah.

Fred R. Brooks, design engineer, Moore Equipment Co. (Mail) 2885 Raymond Ave., Stockton, Calif.

Paul N. Doll, agricultural engineer, Department of Resources and Development, State Office Building, Jefferson City, Mo.

Harold J. Evans, secretary-treasurer and manager, New York Cooperative Seed Potato Assn., Inc., Georgetown, N. Y.

Armon W. Hamilton, manager, rural development, Monongahela Power Co., Fairmont, W. Va.

Fred P. Johnson, cotton ginning and marketing specialist, North Carolina Department of Agriculture, Raleigh, N. C.

William D. Kenney, research assistant in agricultural engineering, University of Georgia, Athens, Ga.

Lester H. McGill, R R No. 3, Tifton, Ga.

Wesley G. Martin, product supervisor, ceramic division, A. O. Smith Corp., 3533 North 27th St., Milwaukee, Wis.

Richard N. Miller, extension agricultural engineer, State College of Washington, Pullman, Wash.

Clifford H. Theriault De Montblanc, research engineer, National Research Council, 405 Metcalfe Avenue, Montreal, P. Q., Canada.

A. D. Mueller, editor, Illinois REA News. (Mail) 910 West Mill St., Carbondale, Ill.

Edward W. Newlin, assistant manager, miscellaneous farm supplies division, Pennsylvania Farm Bureau Cooperative Assn. (Mail) R. D. No. 1, Grantville, Pa.

Ellaf A. Olafson, instructor in agricultural engineering, University of Saskatchewan, Saskatoon, Sask., Canada.

Penumarty V. C. Rao, senior land assistant, Land Improvement Department, Government of Bombay. (Mail) P.V.C. Rao, Gokhlay House, near Darbar High School, Bihapur, India.

Edwin C. Schneider, assistant instructor in agricultural engineering, Cornell University, Ithaca, N. Y. (Mail) 312 University Ave.

Harbhajan S. Sidhu, industrial engineer and manufacturer's representative, No. 26, Darya Ganj (Faiz Bazar) Delhi, India.

Thorvald E. Thoreson, farm specialist, General Electric Supply Corp., 190 No. Broadway, Milwaukee 1, Wis.

TRANSFER OF GRADE

S. H. Byrne, associate professor of agricultural engineering, Virginia Polytechnic Institute, Blacksburg, Va. (Junior Member to Member)

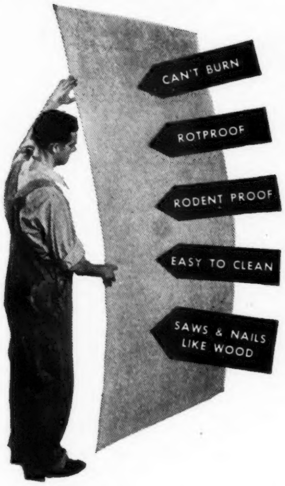
C. E. Carlson, machine designer, Allis-Chalmers Mfg. Co. (Mail) 501 D Street, LaPorte, Ind. (Junior Member to Member)

G. Price Grieve, consulting agricultural engineer, Frank J. Zink Associates, Board of Trade Building, Chicago, Ill. (Junior Member to Member)

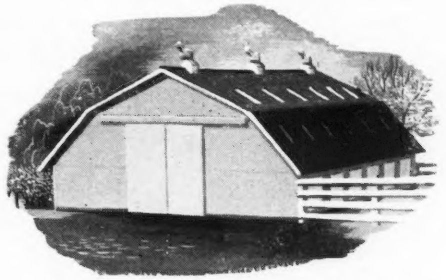
Howard E. Morrison, captain, U. S. Army. (Mail) Suisun, Calif. (Junior Member to Member)

Paul A. Whisler, engineer, Allis-Chalmers Mfg. Co. (Mail) 404 Montrose Street, LaPorte, Ind. (Junior Member to Member)

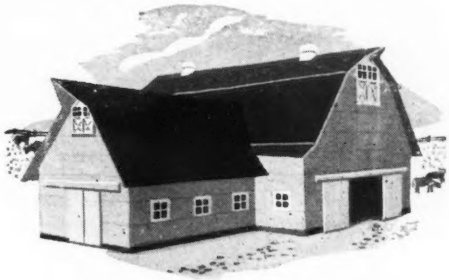
for permanence, economy, fire safety–



specify Johns-Manville Asbestos Flexboard



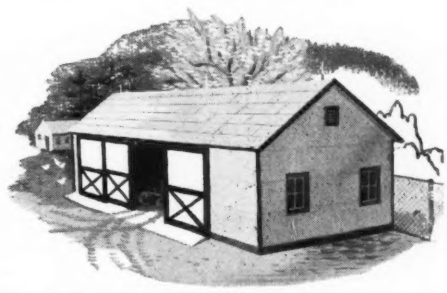
Hog Houses—Flexboard on the exterior walls makes a low-cost, weather-tight building.



Dairy Barns—Inside or out, Flexboard saves money because it needs no painting or whitewash and is easy to keep sanitary.

Quick facts about Flexboard—Made of asbestos and cement, Flexboard is hydraulically pressed and then repressed for extra strength. It has the permanence of stone, yet is inexpensive and easy to work. Comes in large 4′ x 8′ sheets. Has a hard smooth surface that's easy to clean, needs no paint or whitewash. Flexboard is fireproof, rotproof, moisture-proof, rodent-proof. Can be used inside or out for walls, roofs, floors or ceilings on new or remodeled structures.

A free research service—Johns-Manville maintains one of the most complete research laboratories in the world on Building Materials. If you have a special farm building or research problem, write to the farm division about it. J-M will gladly work with you to the extent of its facilities.



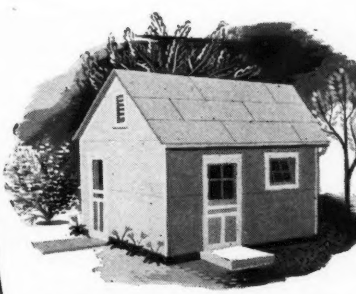
Machine Sheds—Flexboard walls and roof provide quick, low cost, yet permanent construction.

Are your files up-to-date?

Have you got the following Johns-Manville printed material?

1. Farm Idea Book
2. Agricultural Handbook
3. Maintenance & Repair Manual
4. Farm Building Plan Service
5. Low-Cost Farm Structures

Indicate the material you want and write to Johns-Manville, Department AE, 22 E. 40th St., New York 16, New York.

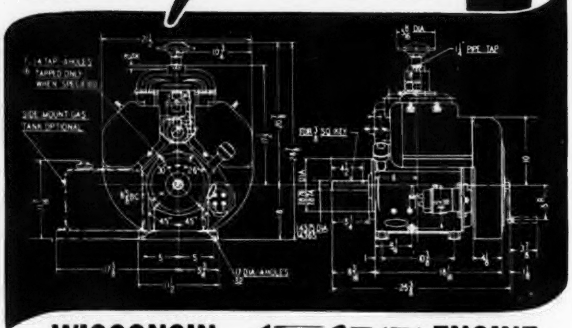


Milk Houses—Flexboard is easy to wash down. Helps meet the most rigid health regulations.

Laying Houses—Flexboard helps fight poultry diseases because it's easy to clean, easy to disinfect.

JOHNS-MANVILLE PRODUCTS **Johns-Manville** **Asbestos Flexboard**

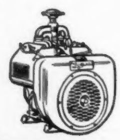
Check ✓ for SIZE



WISCONSIN *Air-Cooled* ENGINE

Model VE4, 22 hp., at 2600 R. P. M.

Extremely compact design is one of the outstanding virtues of Wisconsin V-type air-cooled engines. The reduction of overall engine dimensions, accomplished by V-type construction, permits easily engineered installation on almost any type of farm equipment . . . as indicated by the front and side elevation diagrams of the VE4 standard Wisconsin Engine reproduced above. This model is extensively used for powering combines and hay balers.



Don't overlook Wisconsin Air-Cooled Engines when considering integrated power for your equipment.

Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

Protecting Crops, Machinery, Homes
SISALKRAFT Does It

On farms — like any other business — every dollar saved is that much profit. Wind, rain, sleet, snow — exposure of every kind — can do much damage to harvested crops, machinery, buildings. With Sisalkraft much of this loss can be avoided.

Sisalkraft is ideal for temporary silos — emergency storage of grain — covering hay stacks — protecting machinery — curing concrete — lining poultry houses — protecting the home — plus many other uses. Costs little. Tough, tear-resistant, and waterproof. Can be used again and again.

Sisalkraft is sold through lumber dealers everywhere. Write for folders on Sisalkraft's many farm uses.

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Manufacturers of SISALKRAFT, FIBREEN, SISALATION, SISALTAPE AND COPPER-ARMORED SISALKRAFT

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request.

NOTE: In this Bulletin the following listings still current and previously reported, are not repeated in detail, except in two cases (W-291 and 298) in which changes in copy have been made. For further information see the Personnel Service Bulletin in AGRICULTURAL ENGINEERING for February, 1946:

POSITIONS OPEN: O-412, 430, 434, 448, 452, 458, 464, 465, 470, 471, 474, 475, 479, 480, 481, 482, 483, and 484.

POSITIONS WANTED: W-200, 201, 202, 203, 205, 207, 208, 210, 211, 214, 215, 216, 217, 218, 219, 220, 223, 224, 225, 226, 227, 228, 229, 230, 231, 233, 234, 235, 242, 243, 246, 248, 250, 254, 259, 260, 261, 264, 267, 270, 271, 274, 280, 281, 282, 286, 287, 288, 289, 291, 292, 293, 294, 295, 296, and 297.

POSITIONS OPEN

AGRICULTURAL ENGINEER (associate rank) for farm structures and utilities research in storage of farm products. Southeastern state university. Salary $3900 max. O-485

AGRICULTURAL ENGINEER (instructor rank) for teaching soil and water conservation and surveying. Southeastern state university. Salary $2400 max. O-486

AGRICULTURAL ENGINEER (assistant professor rank) for teaching farm shop, including teacher training and in-service courses. Southeastern state university. Salary $3300 max. O-487

DISTRICT AGRICULTURAL ENGINEERS (2 positions) for educational and service work in agricultural engineering, mainly farm machinery, structures, and drainage, in district of four or five counties. Northeastern state university. Start at $2500. O-488

AGRICULTURAL ENGINEER (assistant professor rank) for college teaching and extension. Northeastern state university. Salary $2700 to $3600. O-489

SALES ENGINEER for sales and advertising covering national distribution to retailers of well known specialized line of farm equipment. Midwestern manufacturer. Salary open. O-490

AGRICULTURAL ENGINEER, for extension work in farm machinery, soil and water conservation, and rural electrification in midwestern state college. Salary open. O-491

AGRICULTURAL ENGINEER (instructor or assistant instructor rank) for teaching farm mechanics and other agricultural engineering subjects in a pacific coast state polytechnic institute which is adding to its curriculum in these subjects. Salary range $230 - $340. O-492

POSITIONS WANTED

AGRICULTURAL ENGINEER (B S deg) desires sales or service work with private company serving agriculture, or in soil conservation or extension work. Long experience in engineering, engineering administration, sales, and promotion work in soil and water conservation field. Veteran of World War 1. Age 57. Salary $3500 min. W-232.

AGRICULTURAL ENGINEER (B S deg) desires development or sales work in power and machinery or product processing field. Age 26. Salary $350 per month. W-236

AGRICULTURAL ENGINEER (B S deg) desires design, development, and research work in rural electrification field for private company or government agency. Age 24. Salary $200 to $250 per mo. W-237

AGRICULTURAL ENGINEER (B S deg) desires development, research or sales and service work in power and machinery with private company, or soil and water conservation work with federal agency. Age 25. Salary $3000. W-238

AGRICULTURAL ENGINEER (B S deg) desires farm machinery sales or service work with private company. Age 23. Salary open. W-239

AGRICULTURAL ENGINEER (B S deg) desires farm machinery sales work with private company. Age 27. Salary $300. W-240

AGRICULTURAL ENGINEER (B S degs in agricultural and mechanical engineering) desires research, design, development, or sales engineering work in power and machinery for private company or in public service. Age 34. Salary $3800. W-241

AGRICULTURAL ENGINEER (B S deg) desires research, design, and development work in power and machinery or product processing field with private company. Age 23. Salary $175 to $200 per mo. W-244

AGRICULTURAL ENGINEER (B S A deg) desires design, development, testing, or experimental work in farm machinery with private company or in public service. Age 28. Salary $200 per mo. W-245

ELECTRICAL ENGINEER (B S deg) desires promotion or operational work in rural electrification field, in midwestern location. Age 25. Salary $3000. W-247

AGRICULTURAL ENGINEER (B S deg) desires rural electrification work, with private company or in public service. Age 28. Salary $2500. W-249

AGRICULTURAL ENGINEER (B S deg in M E) desires agricultural engineering work in Sacramento Valley, Calif. Age 29. Salary $3000. W-251

AGRICULTURAL ENGINEER (B S and M S degs) desires research or development work in rural electrification in Rocky Mountain or west coast area. Age 31. Salary $3000. W-253 *(Continued on page 144)*

It's As Good

AS ITS SKF BEARINGS!

Season after season passes by with this Cutter Head Hammer Mill grinding small grain and roughage without bearing trouble. For this Hammer Mill is as good as its bearings, and its bearings on rotor, cutter head and blower shafts—where *rolling alignment* counts—are six SKF Self-Aligning Ball Bearings. In addition, four SKF Seal Bearings are on the belt tighteners. Wherever there's an SKF, there's high load carrying capacity combined with years of smooth performance with low maintenance costs. That's why manufacturers, dealers and users like their machines to be equipped with *the right bearing in the right place.* 5942

SKF INDUSTRIES, INC., PHILADELPHIA 34, PA.

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ALGOMA FOUNDRY
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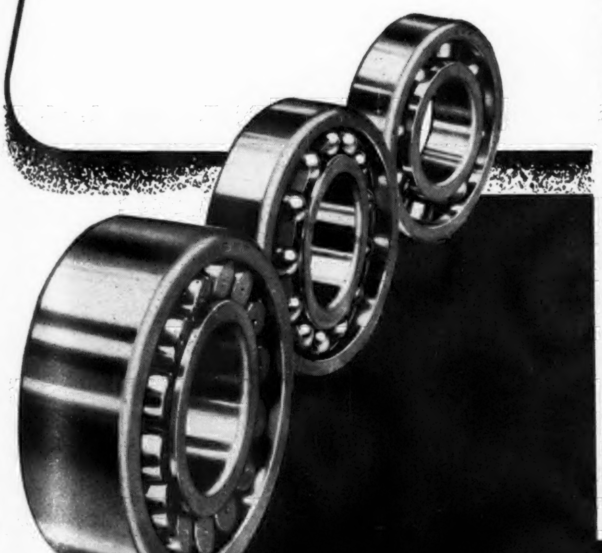
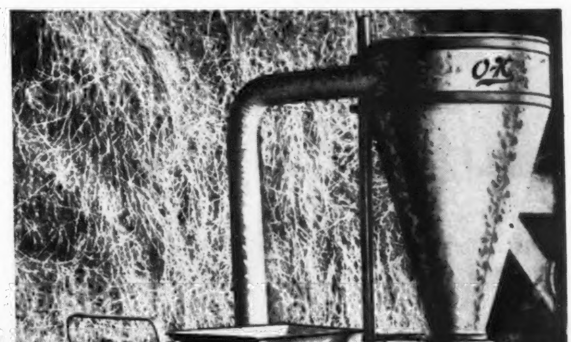
BALL & ROLLER BEARINGS





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This emblem, a mark of **Quality** and **Experience**, means the same as International Harvester. By this symbol Harvester dedicates all its products to the farmer's service.

International Harvester has great things in store for the future on the farm. New products are being built that will make farm operation a more profitable and easier venture. You will recognize them by this symbol — a pledge by International Harvester for leadership in the future of Agriculture.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue **Chicago 1, Illinois**

"GOOD FENCES are necessary for GOOD FARMING"

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PERSONNEL SERVICE BULLETIN

(Continued from page 142)

AGRICULTURAL ENGINEER (B S deg) desires sales engineering or service work with private company in power and machinery or product processing field. Age 25. Salary $3000. W-255

AGRICULTURAL ENGINEER (B S deg) desires work in soil and water conservation, irrigation, or drainage. Age 36. Salary 3600. W-256

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AGRICULTURAL ENGINEER (B S deg) desires development, research, or project engineering work in soil and water conservation in public service or private industry. Age 35. Salary $200 per mo. W-258

AGRICULTURAL ENGINEER (B S deg) desires soil and water conservation work, preferably with private industry, in Southwest. Age 23. Salary $3000. W-262

AGRICULTURAL ENGINEER (B S deg) desires sales and service work in farm machinery or rural electrification, with private company. Age 26. Salary $2400. W-263

AGRICULTURAL ENGINEE8 (B S deg) desires sales promotion, machine, equipment or supply sales; or sales engineering work with private company. Age 26. Salary $2500 to $3000. W-291

ENGINEER, with Civil Service P-3 rating, desires sales work in machinery, rural electrification, or farm structures; college work, or research or project engineering work in a government agency. Age 34. Salary open. W-298

New Literature

"SHOPWORK ON THE FARM," by Mack M. Jones, professor of agricultural engineering, University of Missouri. Cloth, 6x9 inches, 486 pages, 575 figures. McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. Price, $2.24.

This book provides a basic text and reference book in farm shop work dealing simply and directly with tools, materials, operations, processes and activities rather than with jobs or projects, so that it can be used with any jobs or projects that meet local needs and conditions. Organized around all the activities of the farm shop, it includes the following chapters: Providing and equipping a farm workshop; sketching and drawing; woodwork and farm carpentry; painting, finishing, and window glazing; sharpening and fitting hand tools; rope work; harness and belt work; concrete work; soldering and sheet-metal work; cold-metal work; forging, tempering, and welding; pipework and simple plumbing; repairing and reconditioning machinery; maintaining electrical equipment, and definitions of shop terms. Many sections of the book are practically duplicated in picture form with hundreds of special drawings and diagrams used to illustrate steps of processes.

"FARM TRACTOR MAINTENANCE" by I. C. Morrison, professor of agricultural education, in charge of training teachers in farm mechanics, Purdue University. Cloth, $5\frac{1}{2}$x$8\frac{1}{2}$ inches, 202 pages, 155 figures. The Interstate, Inc., Danville, Ill. $2.00.

A text and reference for teachers and tractor users. Chapters on the meaning of preventive maintenance, tractor construction, tractor fuels, oils and greases, maintaining the power plant, maintaining the carburetor, maintaining the lubricating system, maintaining the cooling system, maintaining the electrical system, servicing the engine, servicing the chassis, general suggestions for tractor operation, operation in cold weather, safety precautions, trouble-shooting guide, storing the tractor for long periods, and preparing the tractor for service after storage.